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# Sky at Night

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- ◆ Celestial targets for beginners and experts
- ◆ Start stargazing now with our simple guide
- ◆ Observe all month with 62 night-sky highlights



INSIGHT  
ASTRONOMY   
PHOTOGRAPHER  
OF THE YEAR

See the winning entries inside

## DUST DETECTIVE

Uncovering the secrets of  
comets' smallest particles

## THE SCIENCE OF FICTION

The writers on a quest  
for more science in sci-fi

## 1ST FOR GEAR

8-inch hydrogen-  
alpha solar telescope



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## This month's contributors include...

### MAGGIE ADERIN POCOCK

SKY AT NIGHT PRESENTER



Maggie explores why the constellations that are so

familiar to us will one day disappear. *Page 21*

### LEWIS DARTNELL

ASTROBIOLOGIST



How thick is Europa's crust? The answer to this humdrum

question is vital if we want to send in a space sub, says Lewis. *Page 16*

### JOHN GILBEY

SCIENCE-FICTION WRITER



John tells us how sci-fi authors learn the space

science that helps them write stories based in reality. *Page 71*

### MARTIN LEWIS

OBSERVING EXPERT



Martin explains how to take a 'star test' image to

check your telescope optics using a digital video camera. *Page 81*

# Welcome

The new season is here – here's how to make the most of it



With the image of a fruitful Perseids observing session still bright in the memory (10 meteors, including two very bright green-tinged bolides), the longer nights and the onset of the observing season proper bring

a real sense of anticipation. That's why I'm particularly excited about this issue, packed as it is with this month's best observing targets. Turn to page 40 for Will Gater's suite of eight stargazing challenges for all abilities, and the *Sky Guide* from page 47 for many more.

Many of these targets are easy to find – all you need is a pair of binoculars and, crucially, dark skies; so find your nearest dark site and look up. If you've not experienced dark skies before, it can be daunting – how do you make your way around a sky so full of stars? On page 33 our survival guide will give you the steps you need to keep your feet on the ground, so you can experience the full wonder of the night sky. And there's wonder in abundance on page 63 as we present the winning images of the Insight Astronomy Photographer of the Year 2015 competition.

Before I go, a word of reassurance about the coverdisc, which regular readers may notice has not been included with this issue: we have not cut the bonus content that we know you love – the virtual planetarium, the

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monthly *Sky at Night* BBC TV show and much more. From this month on, all this content can be found in a dedicated area of our website. Just visit [www.skyatnightmagazine.com/bonuscontent](http://www.skyatnightmagazine.com/bonuscontent) and enter the code you'll find on page 5 to access it.

Enjoy the issue, and don't forget to turn your clocks back an hour at 2am on 25 October!

**Chris Bramley** Editor

**PS** Next issue goes on sale 15 October

## Sky at Night LOTS OF WAYS TO ENJOY THE NIGHT SKY...



### TELEVISION

Find out what *The Sky at Night* team will be exploring in this month's episode on page 19



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MAGAZINE



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# Spectral shockwaves

A recent Hubble study of shell galaxies reveals more about the consequences of galactic mergers

HUBBLE SPACE TELESCOPE, 9 JULY 2015

This rather ghostly-looking object is a lenticular galaxy 270 million lightyears away in Centaurus. Lenticulars are unique in that they share the properties of both spiral galaxies and elliptical galaxies.

The spectral appearance of galaxy ESO 381-12 is something of a mystery, as the fuzzy shells that give it its ethereal look are rarely found in this type of galaxy. It is thought that ESO 381-12 could have interacted with another galaxy, causing a ripple effect of shockwaves that spread to its core and altered its evolution fundamentally. Galactic mergers are violent events that trigger star formation and can re-energise ageing galaxies. This theory is supported by the galaxy's uneven structure and the cluster of stars in its orbit.

At the right of the image is ESO 381-13, an active star-forming galaxy with plenty of energy and cosmic dust at its core. These two galaxies are at similar distances from Earth; astronomers suspect they could be interacting with one another.

## Little Gem ►

HUBBLE SPACE TELESCOPE

2-3 AUGUST 2015

The glow of cloud seen here in the Little Gem Nebula in Sagittarius is just over half a lightyear across, which is enormous compared to the size of its central star. Planetary nebulae like this form when central stars begin to shed their outer layers and create glowing clouds of gas. The intricate and varied shapes of these nebulae are a result of the unevenness of the shedding process.



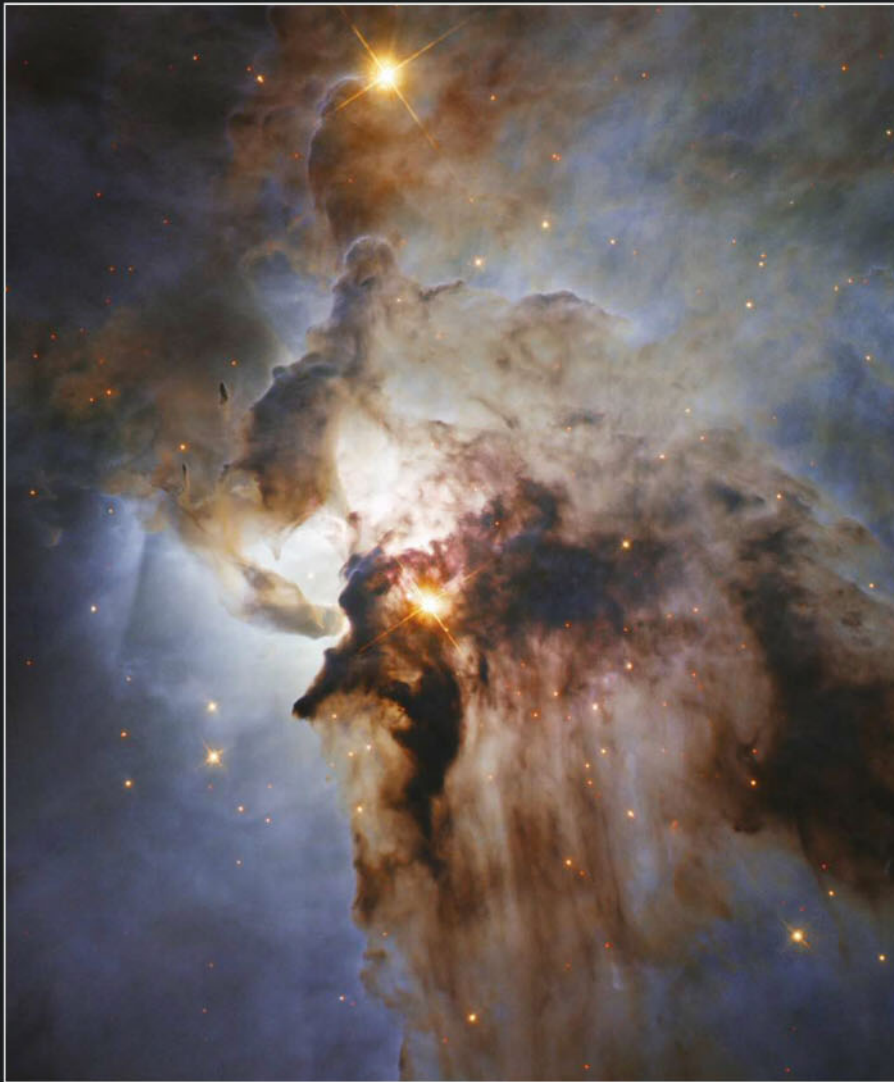
## ▼ Galactic warp

HUBBLE SPACE TELESCOPE

10 AUGUST 2015

NGC 428 is a barred spiral galaxy about 48 million lightyears away in Cetus. These galaxies are so-called because they contain a 'bar' structure of stars within their spiral shape. NGC 428 is a particularly interesting example because its shape has become warped, perhaps as a result of a galactic collision. The collision theory is strengthened by the fact that the galaxy is an energetic, star-forming region – a property that may have been precipitated by the merger of gas clouds from two separate bodies.





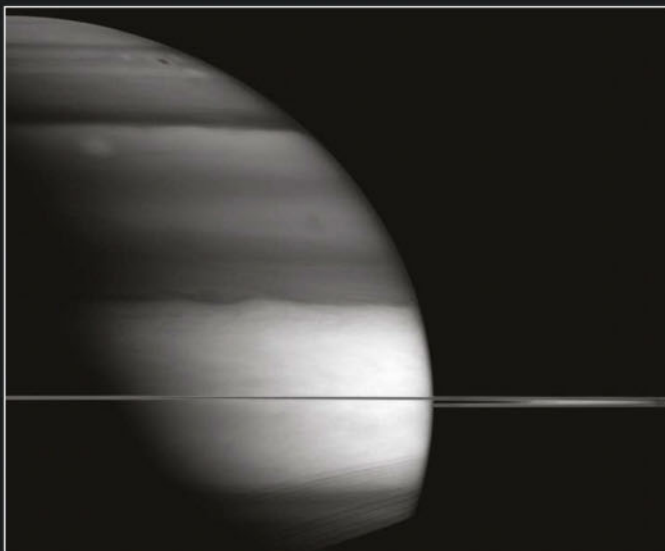
## ◀ The choppy lagoon

HUBBLE SPACE TELESCOPE, 30 JULY 2015

This image of the heart of the Lagoon Nebula shows the hot hive of activity at its core. Scorching stars blow intense winds into and around the region, while new stars burst into life amid a haze of gas and dust.

The use of infrared as well as visible light in this Hubble image cuts through some of this dark dust and glowing gas, which would otherwise obscure much of the activity. As a result, a more intricate depiction of the nebula is revealed, providing a typically chaotic yet beautiful image.

The bright star at the centre of the image is Herschel 36. It strips away the surrounding cloud and cosmic material, thus sculpting and forming the nebula's shape.



## ▲ Cassini captures the Ringed Planet

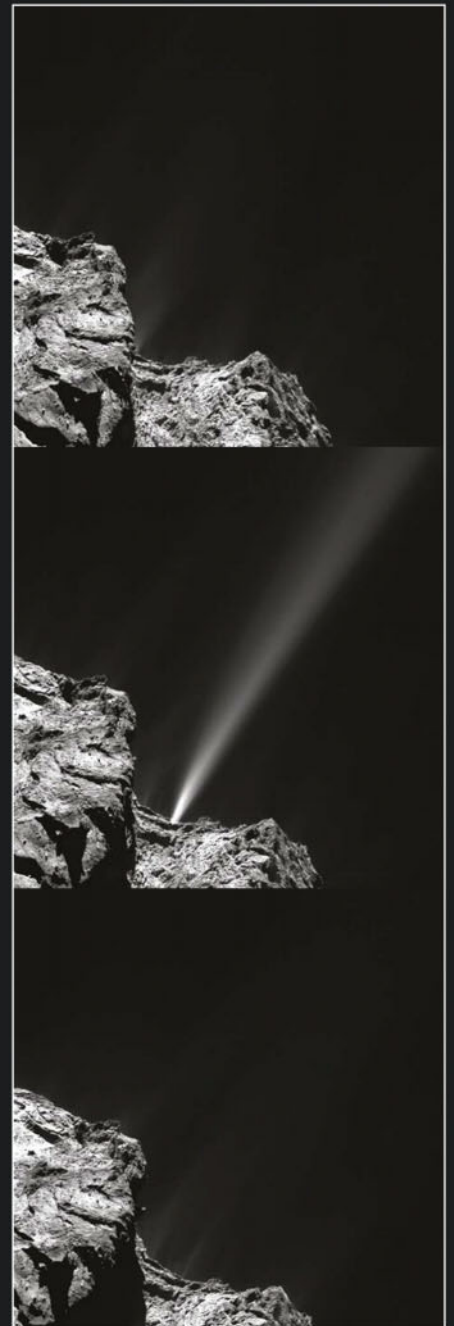
CASSINI SPACECRAFT, 10 AUGUST 2015

Saturn is imaged here using a filter on Cassini's wide-angle camera that is sensitive to infrared wavelengths absorbed by methane. Darker areas in the image depict clouds lower in the atmosphere, where more methane is present, while lighter areas show clouds of higher altitude and with lower methane levels.

## Perihelion power ▶

ROSETTA SPACECRAFT,  
11 AUGUST 2015

ESA released this image of a jet of gas and dust bursting from comet 67P/Churyumov-Gerasimenko as it approached its closest point to the Sun – perihelion. The jet is one of the brightest seen so far by the Rosetta team, and was caused by melting ice within the comet turning to gas and shooting out into space, dragging dust with it.



ESA/HUBBLE & NASA, ESA/HUBBLE AND NASA AND S. SMARTT (QUEEN'S UNIVERSITY BELFAST) - ACKNOWLEDGEMENTS: NICK ROSE AND FLICKR USER PENNINECLOUD, NASA/ESA/J. TRAUGER (JET PROPULSION LABORATORY), NASA/JPL/Caltech/SPACE SCIENCE INSTITUTE, ESA/ROSETTA/MP

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# Bulletin

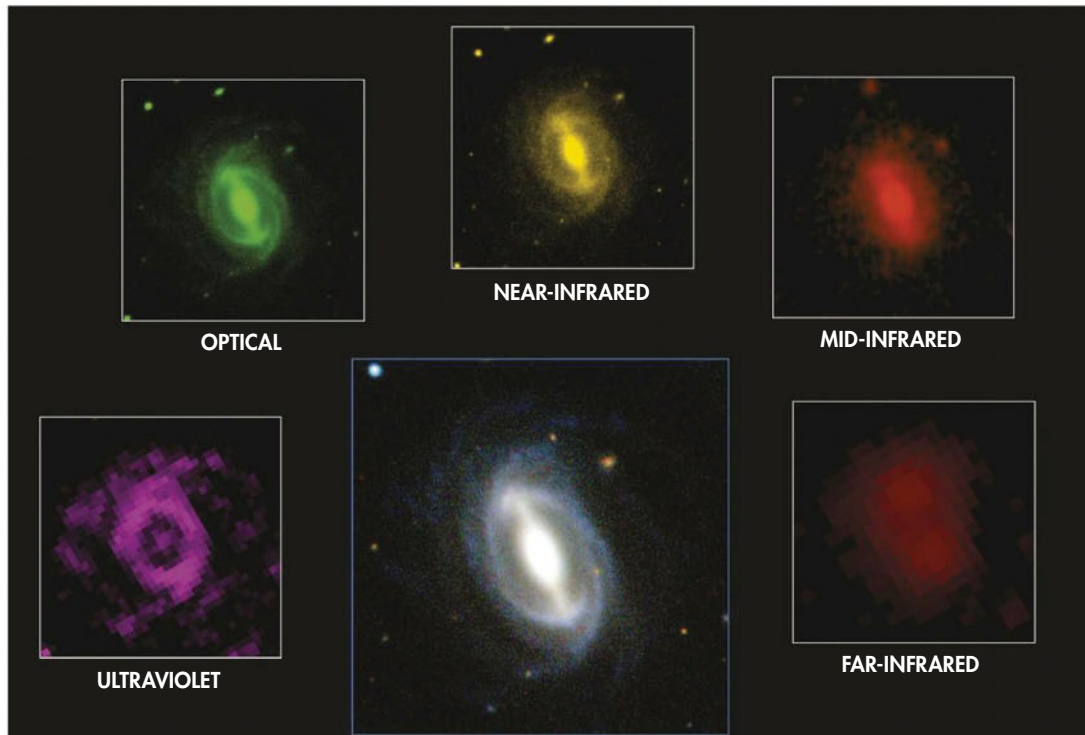
PLUS  
CUTTING

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EDGE

The latest astronomy and space news written by **Elizabeth Pearson**

Our experts examine the hottest new astronomy research papers



▲ How a typical galaxy appeared to the GAMA survey, viewed across the electromagnetic spectrum

## Energy output of Universe in decline

The Universe is getting ready to put its feet up for the night

THE ENERGY OUTPUT of our Universe has been shown to be half what it was as little as two billion years ago. The finding comes from a study of over 200,000 galaxies, and suggests we live in a realm in decline.

The study forms part of the Galaxy And Mass Assembly (GAMA) project and used a range of telescopes to measure across several wavelengths from the infrared to the ultraviolet to get the most complete view.

"We used as many space and ground-based telescopes as we could get our hands on to measure the energy output of over 200,000 galaxies across as broad a wavelength range as possible," says Simon Driver from The University of Western Australia. The aim of the survey was to create a 'map' of the

energy output of the nearby Universe. This energy stems from the moment the Universe was born during the Big Bang, and much of it has since been locked up as mass in atoms. During the Universe's first few billion 'teenage' years, it formed stars that transferred the mass back to energy as light.

The survey showed that this output has decreased dramatically over the last few billion years, indicating that the Universe is beginning to wind down.

"The Universe will decline from here on in, sliding gently into old age," says Driver. "The Universe has basically sat down on the sofa, pulled up a blanket and is about to nod off for an eternal doze."

► See Comment, right



### COMMENT by Chris Lintott

There's little to surprise astronomers in this news from the GAMA survey. We've known for a couple of decades now that our Universe is past its best. Yet this story was everywhere, a useful hook for getting the story of the release of data from a new survey out into the media.

Does the idea of a dying Universe make you uncomfortable? Somehow, it seems preferable to live in a vibrant Universe with its most active days still ahead of it. Imagine the tales we could tell about the maelstroms to come.

But be careful what you wish for. More star formation means more supernovae, and hence an increase in the influx of high-energy particles known as cosmic rays heading for our fragile Earth. Maybe we're better off curled up in the Universe's quieter time of life. After all, the magic of astronomy is that surveys like GAMA get to look back and see what a more exciting time was like.

CHRIS LINTOTT co-presents *The Sky at Night*

## NEWS IN BRIEF

### ASTRONAUTS DINE ON SPACE VEGGIES

Vegetables grown on board the International Space Station have been eaten by the crew, the first time that space grown produce has formed part of someone's dinner. The red romaine lettuce was grown in the VEGGIE experiment where seeds were planted into inflatable pillows filled with special clay, imbued with fertiliser and lit with LEDs

"The farther and longer humans go away from Earth, the greater the need to be able to grow plants for food, atmosphere recycling and psychological benefits," says Gioia Massa, VEGGIE lead scientist.



### MORE DWARF GALAXIES FOUND NEAR MILKY WAY

Eight new dwarf galaxies have been found around the Milky Way as part of the Dark Energy Survey (DES), taking the total discovered by the project up to 17. Many of the observations were made around the Milky Way's two largest satellites, the Large and Small Magellenic Cloud suggesting the new finds are satellites of satellites.



NASA, ESA/NASA, DANIELLE FUSELAAR AND FRANCK MARCHIS/SETI INSTITUTE, NASA/ESA AND R. FOLEY (UNIVERSITY OF ILLINOIS), SOHO CONSORTIUM/ESA/NASA, NASA/ESA AND THE HUBBLE HERITAGE TEAM (STSC/IAURA), NASA/JPL-CALTECH/T. PYLE (SSC)

Unlike most alien worlds, Jovian exoplanet 51 Eridani b has been seen directly

# Youthful Jupiter exoplanet found

The alien world is the first discovered using the Gemini Planet Imager

A JUPITER-LIKE PLANET has been discovered in a planetary system around a very young star. The planet, 51 Eridani b, was discovered with the Gemini Planet Imager (GPI) and is around 100 lightyears away.

The planetary system, and the star it surrounds, was only formed 20 million years ago. Finding a star so young and so close by has made the young planet a prime target for follow up study, as it could yield clues about the evolution of Jupiter. Though it is roughly twice the mass of Jupiter, this means it is half the mass of other young planets discovered so far.

"This planet really could have formed the same way Jupiter did," says Bruce Macintosh from Stanford University. "The whole solar system could be a lot like ours."

51 Eridani b is cooler than Jupiter, with temperatures of only 420°C, rather than the 650°C seen on most other gas giants, but it does have a very similar atmosphere to our mighty planet, containing high quantities of methane. While the gas giants of our Solar System are rich in this

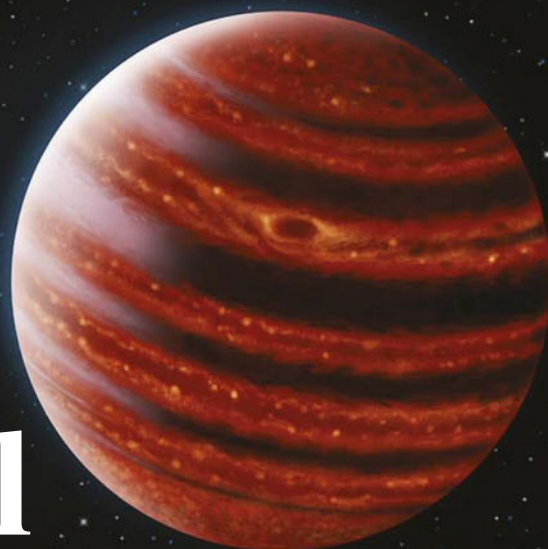
gas, exoplanets have tended to have more carbon monoxide.

"Many of the exoplanets astronomers have imaged before have atmospheres that look like very cool stars," says Macintosh. "This one looks like a planet." The exoplanet's resemblance to Jupiter could be important to understanding how our own Solar System formed, as the largest planet has had a dramatic effect on the evolution of all the others in the system.

The discovery is the first to be made with the GPI, which differs from previous exoplanet surveyors as it looks for the planets directly, rather than through the dip in brightness caused by the planets transiting in front of their host star, as Kepler did. Most of the starlight is blocked off, allowing the instrument to pick up on the faint reflected light of the planet. The planetshine is three million times fainter than the star, but GPI can clearly pick out its signal.

"To detect planets, Kepler sees their shadow," says Macintosh. "The Gemini Planet Imager instead sees their glow, which we refer to as direct imaging."

[www.planetimager.org](http://www.planetimager.org)



## NEWS IN BRIEF

### COMETS MAY HAVE SPARKED LIFE

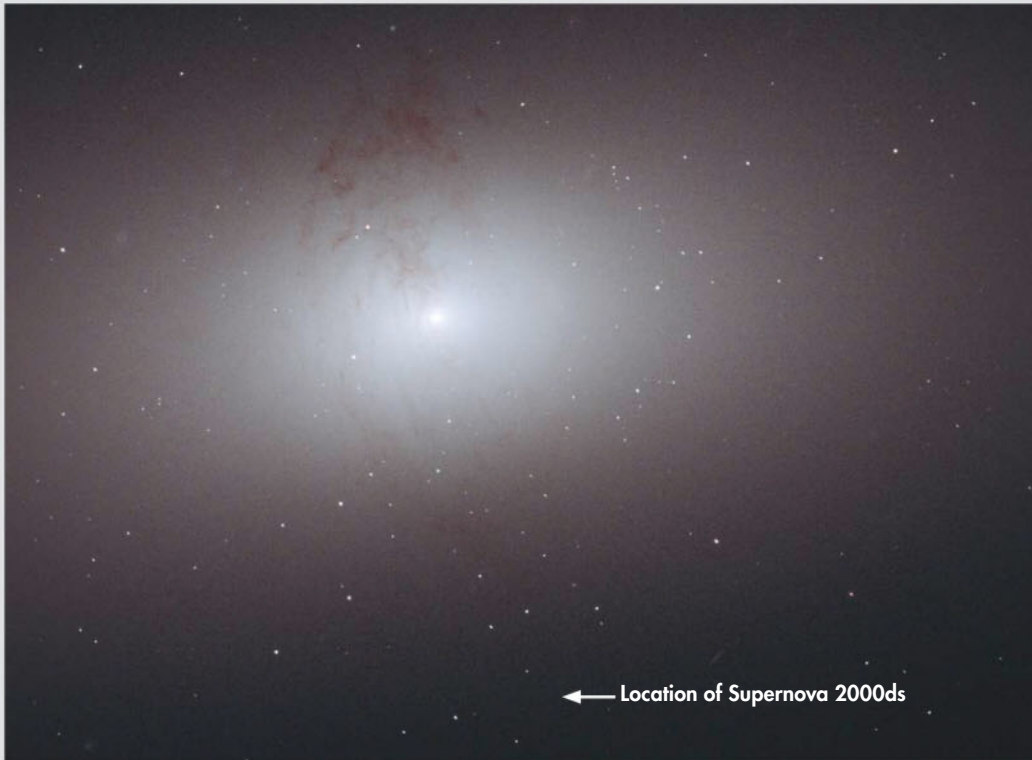
Comets contain complex molecules necessary for life, but it's uncertain how these go on to form life. It seems the impact itself may be the key. Scientists in Japan recreated a comet then simulated the shock of an impact. Short peptide chains were found in the resulting mixture.

"The production of short peptides is the key step in the chemical evolution of complex molecules," says Haruna Sugahara from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).



### SUPERNOVA SPURRED SPINNING SOLAR SYSTEM

The supernova shockwave that kicked our Sun into life may have also set the Solar System spinning, according to new simulations. "The very fact that a rotating disc formed around our proto-Sun may have been a result of the spin induced by this shock front," says Alan Boss from the Carnegie Institution. "Without spin, the cloud disappears into the proto-Sun. With spin, a disc suitable for planet formation is created."



▲ Supernova 2000ds is one of this class; it is at least 12,000 lightyears from its galaxy, NGC 2768

## Lonely supernovae found in space

The isolated dying stars have been turfed out of by black holes

SUPERNOVAE ARE BEING observed half a million lightyears from any galaxy. It's believed that the stars might have met their lonely demise after being ejected from their galaxies by the chaotic forces generated by spiralling pairs of black holes.

Researchers struggled to explain how the supernovae happened in deep space away from other star clusters and galaxies but tracking the supernovae's speed showed they were all

travelling in excess of 7.2 million km per second and originated in merging galaxies.

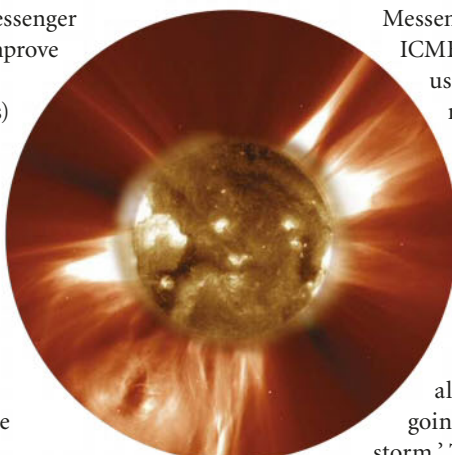
"There is only one way to get a binary star system moving that fast: a slingshot from a close flyby of a binary supermassive black hole," says Ryan Foley from the University of Illinois. "How do you get a binary supermassive black hole? Merge two galaxies."

[www.keckobservatory.org](http://www.keckobservatory.org)

## MERCURY PROBE HOLDS SOLAR SECRETS

READINGS FROM NASA's Messenger probe to Mercury could help improve predictions about interstellar coronal mass ejections (ICMEs) and the geomagnetic storms they produce.

"Messenger was the first spacecraft since the 1980s to make measurements of the interplanetary medium close to the Sun," says Reka Winslow from the University of New Hampshire. "The resulting data presents a unique opportunity for studying the evolution of ICMEs as they expand and propagate outward well before they reach Earth."



▲ Our star is beautiful but violent; a really strong geomagnetic storm could cause disruption on Earth

Messenger's magnetometer measured ICMEs, and now researchers are using the information from the readings to create better models of how ICMEs behave as they move away from the Sun to determine if they could be damaging. "You want that forecasting power so you can say, 'Even though we know this ICME will hit the Earth, its magnetic field direction is aligned in such a way that it's not going to cause a geomagnetic storm.' That's something we're testing right now with the observations from Messenger," says Winslow. <http://messenger.jhuapl.edu>

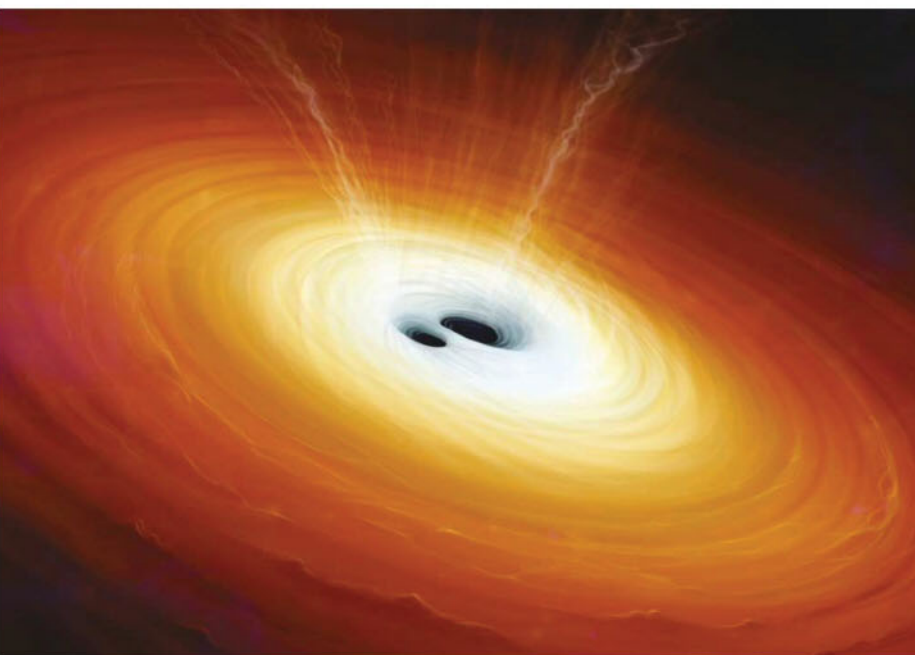
## CUTTING

Our experts examine the hottest new research

## EDGE

## Supermassive binaries

Black holes spiralling towards each other appear to flicker, meaning we can track down merging pairs



**G**alaxies merge. We know this – we see the spectacular train wrecks that result littering the sky. And most, if not all, galaxies have a supermassive black hole at their centre – the one in the Milky Way weighs in at the equivalent of a few million solar masses. So it stands to reason that when two galaxies have merged, their black holes must eventually merge too.

The logic is impeccable, but as usual the devil is in the details. Large black holes from two newly merged galaxies will form a binary system easily enough, but getting them close enough to merge takes a series of interactions with their surroundings. First, interaction with nearby stars strips the binary of gravitational energy, causing the black holes to spiral closer together. As they approach the centre of the galaxy, hot gas concentrated near the galactic nucleus can play the same role. Finally, when the two enormous black holes are close enough, their movement ripples the fabric of space itself, causing the binary to lose energy through gravitational waves.

If this sounds complicated, it is. To understand what's really going on we need real examples to study, and a new paper from British-born Caltech

▲ One cause of the flickering may be that their accretion discs are warping



**CHRIS LINTOTT** is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project.

astronomer Matthew Graham and colleagues provides just that. They used data from the small telescopes of the Catalina Sky Survey, which have been measuring the brightness of thousands of quasars for most of a decade.

However, these records aren't the easiest to work with, as any particular object is observed only at irregular intervals, but using careful analysis the team can pick out the regular flickering that represents two black holes in close orbit around each other. They found 111 black hole pairs in the data, typically with masses of around 100 million Suns in orbit around each other every 10 years.

Despite being able to use this flickering to detect black hole pairs, it's still not clear exactly what causes it. It doesn't come from the black holes themselves, but from the material surrounding them. One possibility is that the presence of two black holes instead of one warps the accretion disc surrounding them, so that we're sometimes viewing more of the bright surface. Other possibilities include complex behaviour involving jets launched by the powerful magnetic fields likely to be present in any such system, or the

**“The team found 111 black hole pairs, typically with masses of around 100 million Suns”**

result of clumping in the accretion disc caused by the presence of the second black hole.

Studying these systems will tell us a lot about black hole physics, and this is an important catalogue. There is, however, one disappointment. It's hoped that experiments looking for gravitational waves might be able to detect black hole mergers directly in the next few years. Unfortunately, it seems that none of the binaries found by this survey are due to collide within the next century; gravitational wave physicists will have to find their own sources. In the meantime, we astronomers will be keeping a close eye on these systems, enjoying our new view of the mysterious objects that lurk at the heart of galaxies.

**CHRIS LINTOTT** was reading... *A systematic search for close supermassive black hole binaries in the Catalina Real-Time Transient Survey* by Matthew J Graham et al  
Read it online at <http://adsabs.harvard.edu/abs/2015arXiv150707603G>

## NEWS IN BRIEF

### OBSERVATORY ACKNOWLEDGES MERIDIAN LINE DISCREPANCY

In recent years visitors to the Royal Observatory Greenwich may have noticed that when they stand by the Airy Transit Circle, which marks the Greenwich Meridian, GPS systems put 0° longitude 102m to the east.

The reason is that when satellites became the dominant method of time keeping, the reference system moved from being Earth-based to space-based. The latter is based on the global gravitational profile of the Earth, and so while this was originally based on the Greenwich Meridian, it drifts as the continents move at a rate of about 2.5cm a year.



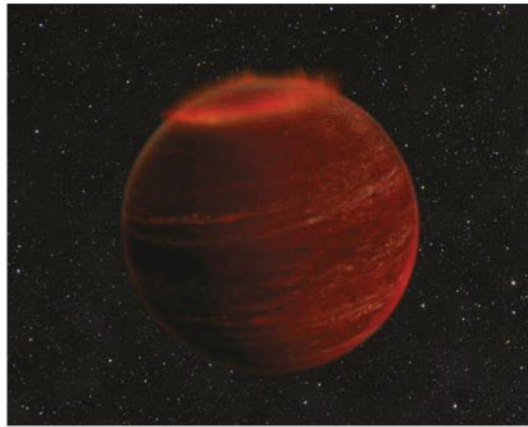
### CHILEAN PEAKS NAMED FIRST DARK SKY SANCTUARY

The Gabriela Mistral Dark Sky Sanctuary has been announced as the first site of its kind by the International Dark Sky Association. Located in the Andean mountains in Chile, the region has long been home to several astronomical observatories.



# Aurorae seen around failed stars

The light shows could be a million times brighter than Earth's



▲ The aurora, the first detected outside the Solar System, is more powerful than any seen before

BROWN DWARFS MAY have aurorae. The discovery is unusual as there is no solar wind, the main mechanism that drives aurorae in our own Solar System. "This is a whole new manifestation of magnetic activity for that kind of object," says Leon Harding, from NASA's Jet Propulsion Laboratory.

The discovery was made after radio emissions with no obvious cause were observed coming from a brown dwarf 18 lightyears from Earth. Follow up observations showed changing light intensity, suggesting aurorae. "We now know that this kind of auroral behaviour is extending all the way from planets up to brown dwarfs," says Gregg Hallinan from California Institute of Technology.

[www.jpl.nasa.gov](http://www.jpl.nasa.gov)

## RARE COLLISION HIDDEN BY MILKY WAY

TWO COLLIDING GALAXIES have been spotted hiding behind the Milky Way. The collision has caused shockwaves to compress gas within these galaxies, creating new stars and forming a bright ring. This is the closest collision of this kind ever seen, only 30 million lightyears away.

"Not only is this system visually stunning, but it's close enough to be an ideal target for detailed study," says Quentin Parker at the University of Hong Kong. "The ring is also quite low in mass – a few thousand million Suns, or less than one per cent of the Milky Way – so our discovery shows that collision rings can form around much smaller galaxies than we thought."

[www.physics.hku.hk](http://www.physics.hku.hk)



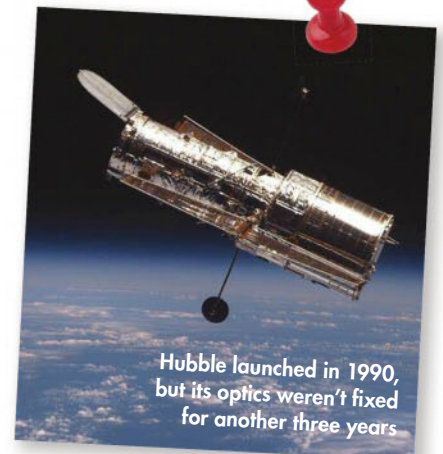
One of the galaxies has formed a ring around the other, creating what scientists call a 'bulls-eye' collision

## Looking back The Sky at Night

### October 1991

On 20 October 1991, the team looked at the work being done by the Hubble Space Telescope, which launched the previous year. Unfortunately in 1991 the telescope still suffered from spherical aberration caused by a flaw in the mirror. With some clever data reduction, researchers were able to improve the images sent back by the telescope, but the problem was not fixed until the first servicing mission in 1993.

Since then Hubble has gone on to capture some of the most famous space images ever seen. It has helped to measure the age of the Universe, find black holes at the centre of galaxies and chart the birth and death of stars. It recently celebrated its 25th anniversary, but is now beginning to show its age. It is hoped Hubble will last until at least 2018 when its spiritual successor, the James Webb Space Telescope, is expected to launch.



Hubble launched in 1990, but its optics weren't fixed for another three years

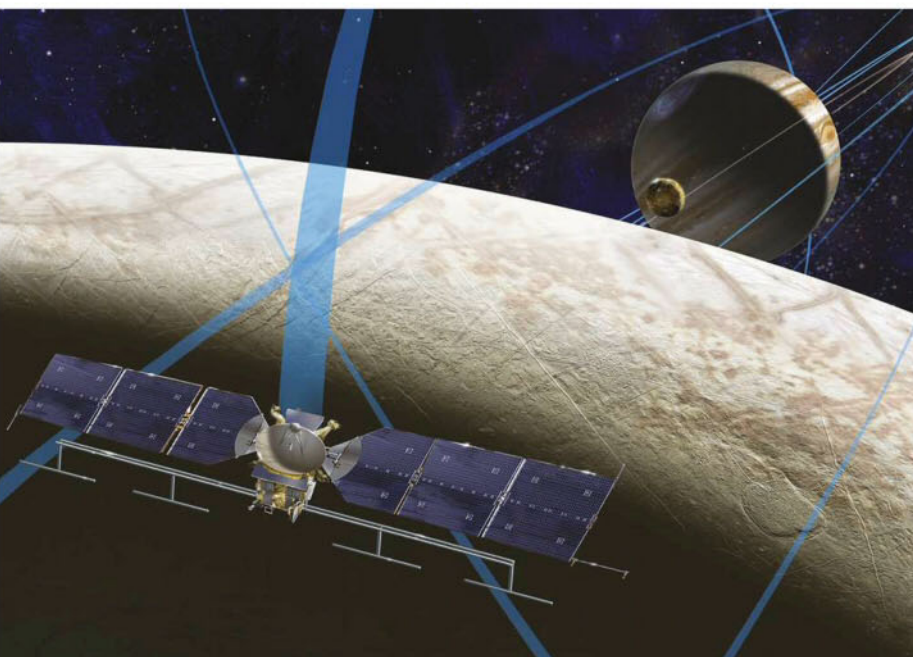
## CUTTING

Our experts examine the hottest new research

## EDGE

## Europa's crust conundrum

Working out the thickness of the Jovian moon's icy shell is imperative if we want to explore underwater



**E**uropa, one of Jupiter's mysterious icy moons, poses one of planetary science's great mysteries – just how thick is its ice shell? Various lines of evidence (including magnetic field data from the Galileo probe in the late 1990s) point to the existence of a global salty ocean hidden away beneath the moon's frozen face, but the debate rages fiercely between scientists as to how thick the icy cap sealing it in is.

One way that the interior structure of Europa can be inferred is by closely watching how the shape of the moon changes slightly as it is pulled and flexed throughout its orbit within Jupiter's powerful gravitational field. Though subtle, these deformations of the moon by tidal forces could be measured by a probe, say Ryan Park and his colleagues at the Jet Propulsion Laboratory in Pasadena, California.

The researchers point to two main methods. As the shape of Europa is pulled out of a true sphere, this will in turn affect the gravitational field experienced by a nearby probe, and these changes in the probe's velocity can be detected from Earth by measuring the Doppler shift in its radio signals. Astoundingly, the line-of-sight velocity of a space probe travelling at tens of thousands of kilometres

▲ The Europa Clipper mission will launch in the 2020s



**LEWIS DARTNELL** is an astrobiologist at University of Leicester and the author of *The Knowledge: How to Rebuild our World from Scratch* ([www.the-knowledge.org](http://www.the-knowledge.org))

an hour can be measured in this way to an accuracy of around 0.1mm per second. Secondly, physical distortion of the moon's surface can be measured in high-resolution photographs by precisely tracking how surface features such as craters bulge out or relax back down again over the moon's orbit, in the same way Earth's oceans respond to tidal forces on our Moon.

What's more, Park and his team show that such an approach can be achieved accurately enough with a mission offering multiple flybys and so not needing a probe actually in orbit around the moon. Such a dedicated Europa orbiter probe is still probably a fair way in the future as the moon sits right in the trapped radiation belt around Jupiter, and this intense particle bombardment would play havoc with a probe's instruments, computers and solar panels.

Luckily, just such a mission is currently under development by NASA for launch in the 2020s: the Europa Clipper. This mission will avoid the

**“The mission will avoid Jupiter's radiation belts, passing Europa over 40 times”**

radiation belt as far as possible by following a looping trajectory around Jupiter, but which swings it close past Europa over 40 times.

By taking reasonable estimates of the specifications of the Europa Clipper's onboard instruments (such as the resolution of the camera system) and the probable flyby trajectories, Park believes they will be able to constrain the thickness of Europa's ice shell to an accuracy of around 10km. This will help develop models of the tidal heating the moon experiences.

There is another reason for determining the thickness of the European ice shell. It will be critical knowledge if there is to be a mission designed for landing on the moon's surface and then drilling or melting its way through that ice cap to explore the ocean, and potentially seek out signs of primitive marine life.

**LEWIS DARTNELL** was reading... *Improved detection of tides at Europa with radiometric and optical tracking during flybys* by Ryan S Park et al  
Read it online at [www.sciencedirect.com/science/article/pii/S0032063315001099](http://www.sciencedirect.com/science/article/pii/S0032063315001099)

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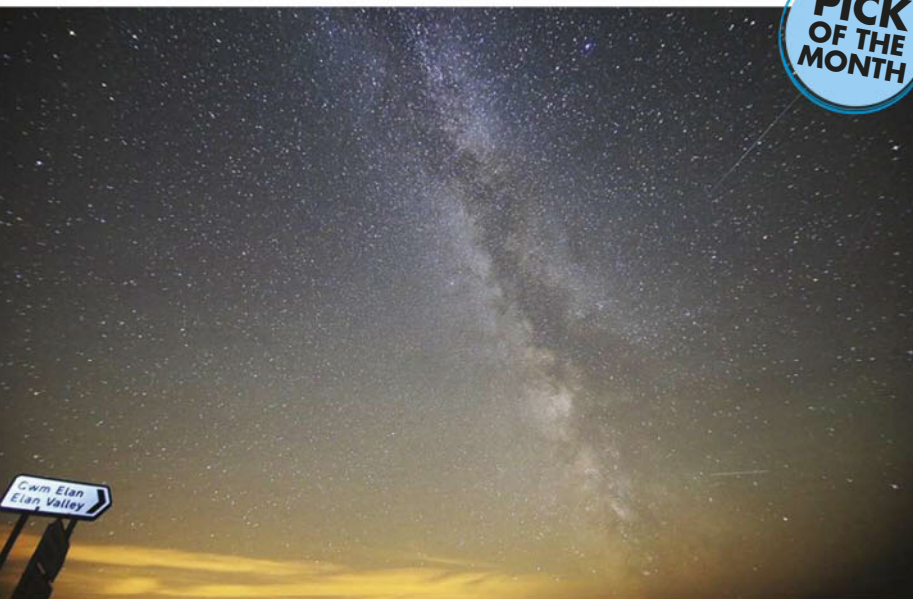
# What's on

Our pick of the best events from around the UK

## Elan Valley 'Dark Sky' Opening

Elan Valley Estate Visitor Centre, Powys, 29 October, 10am

PICK  
OF THE  
MONTH



### ▲ Elan Valley Estate's pristine skies have earned it International Dark Sky Park status

Elan Valley Estate in the Cambrian Mountains has recently been accredited with International Dark Sky Park status by the International Dark Sky Association (IDA), meaning the 45,000-acre estate is now protected against light pollution. The award follows more than 200 light readings at 13 sites over a 22-month period to assure the estate met the necessary criteria.

To celebrate, the park is staging a Family Astronomy Day at its onsite visitor centre, offering a range of

astronomy events including talks, solar observing sessions, photographic displays and evening observing (weather permitting). Members of the Elan Valley Astronomy Group will be on hand to offer advice and guidance to those new to the world of stargazing. Entry is free, but spaces for individual talks are limited. Contact the visitor centre on 01597 810880 for further information and to keep up to date with the events programme. [www.elanvalley.org.uk](http://www.elanvalley.org.uk)

## BEHIND THE SCENES THE SKY AT NIGHT IN OCTOBER

**BBC** Four, 11 October, 10pm (first repeat **BBC** Four, Thursday 15 October, 7.30pm)\*



Black plumes of material from Triton's volcanoes were imaged by Voyager

### VOLCANOES

We think of volcanoes as some of the most powerful natural phenomena on Earth, but ours are nothing compared to those elsewhere in the Solar System. From the extinct giants of Mars, to the sulphur plumes of Io and the cryovolcanoes on Triton, this month's Sky at Night reveals the volcanism on other planets and moons.

\*Check [www.bbc.co.uk/skyatnight](http://www.bbc.co.uk/skyatnight) for subsequent repeat times

## A Beginner's Guide to Stargazing

Royal Observatory Edinburgh, 26 October, 7.30pm



The yearly Winter Talks programme begins at the Royal Observatory Edinburgh with a 'Beginner's Guide to Stargazing'. This is the first in a series of talks taking place every Monday held by experts

for the general public. Admission is £3 for adults, £1.50 for children and concessions. Season tickets are £20 for adults, £10 for children and concessions. [www.roe.ac.uk/vc](http://www.roe.ac.uk/vc)

## Sir Patrick Moore Auction Sale

Henry Adams Auctioneers, Baffins Hall, Baffins Lane, Chichester, 8 October, 10am



Going under the hammer in the official auction of contents from Farthings, the home of Sir Patrick Moore, will be musical instruments, furniture, pictures, books and personal effects collected over a lifetime in astronomy. Lots will be available to view at the showroom on the Tuesday and Wednesday before the auction, and online a week before.

[www.henryadamsfineart.co.uk](http://www.henryadamsfineart.co.uk)

## Space Week Star Party

Haw Wood Farm, Hinton, Suffolk, 9-12 October



Breckland Astronomical Society hosts its Autumn Star Party at Dark Sky Discovery Site Haw Wood Farm this month as part of its Space Week activities. The event welcomes both expert and amateur astronomers for a weekend of camping and stargazing. Pitches are £10 per night, £15 including electric hook-up.

[www.hawwoodfarm.co.uk](http://www.hawwoodfarm.co.uk)

[www.brecklandastro.org.uk](http://www.brecklandastro.org.uk)

## MORE LISTINGS ONLINE

Visit our website at [www.skyatnightmagazine.com/whats-on](http://www.skyatnightmagazine.com/whats-on) for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the page.



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# A PASSION FOR SPACE



with **Maggie Aderin-Pocock**

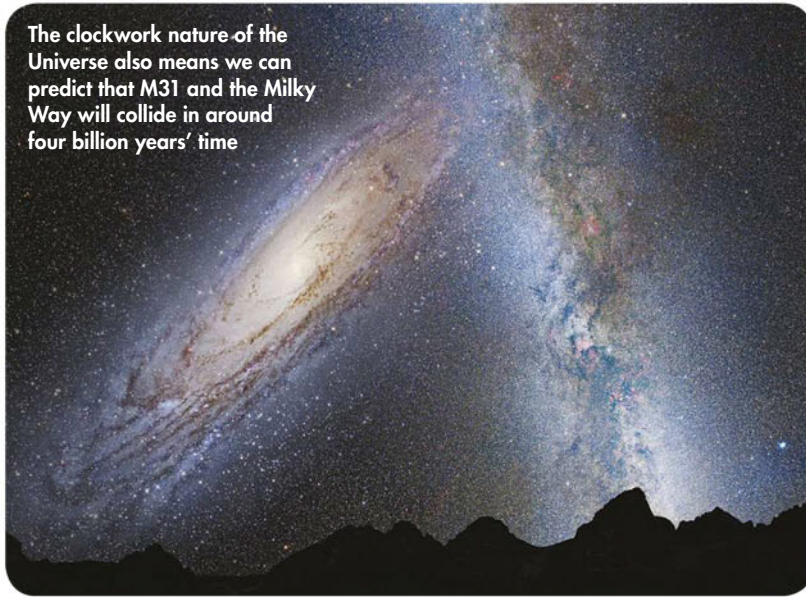
*The Sky at Night* presenter considers a future where the familiar constellations are warped beyond recognition

**F**or many years now I have been fascinated by the subject of archaeoastronomy, the study of astronomy by ancient cultures. There is something quite magical about looking at the stars in the knowledge that our ancestors looked at the same view, serene and unchanging. I also find it fascinating that virtually every culture through history has been fascinated by the night sky. They have drawn pictures, made monuments and catalogued what is out there.

The first star catalogues on record were produced by the Chinese around 2300 BC, with Babylonians making the first almanacs as early as 750 BC. By observing the Universe, they hoped to predict what was going to happen in the future. In many ways the Universe appears to be static and unchanging – constellations named by the Greeks are still with us today – but there were a few clues that pointed towards things not being as inert as they appeared.

On a local level it was the movement of the Solar System's planets through the night sky that provided some of the first evidence that our planet Earth was not at the centre of the Universe as we thought. With Newton's discovery of gravity in 1665 we entered the era of

The clockwork nature of the Universe also means we can predict that M31 and the Milky Way will collide in around four billion years' time



the clockwork Universe, with gravity as the glue that keeps it running predictably. Now, with knowledge of a few parameters, the handle of the clockwork Universe could be wound both forwards and backwards to predict the future and look into the past, revealing the dynamic nature of the Universe.

## The shifting stars

We discovered that depending on your time and distance scale the Universe can seem very changeable, and that we can actually detect the movement of some stars just by looking with a telescope. Barnard's Star in the constellation of Ophiuchus is the second-closest star to us after Alpha Centauri. It's a dim 10th-magnitude star not visible with the naked eye, but by

recording its positions over the months and years we can see it moving relative to the background stars.

This is called proper motion and is defined as a gradual change in the position of a star or other object on the celestial sphere, which is the result of the object's intrinsic motion through space rather than its apparent motion as observed from Earth. Given enough time we could detect the proper motion of all the stars. And because of proper

motion the constellations that we take for granted will, given time, move so that the patterns will be unrecognisable.

We can use the clockwork Universe to predict an event that will change our night skies forever. In around four billion years our Galaxy, the Milky Way, will collide with the Andromeda Galaxy. Although it is unlikely that the stars will collide with each other the event will be spectacular: the two galaxies will merge to form a huge elliptical galaxy. When this happens the view of stars from Earth will change utterly. The constellations viewed by our ancestors may be safe for now, but in the distant future things will be very different. **S**

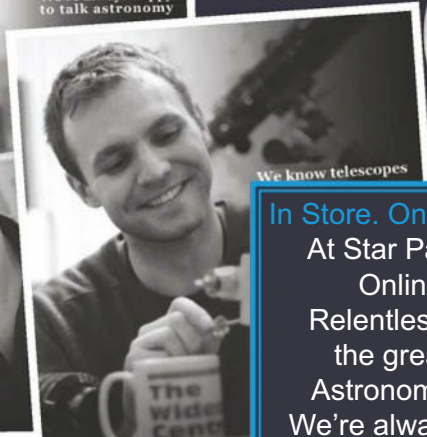
Maggie Aderin-Pocock is a space scientist and co-presenter of *The Sky at Night*

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August - [www.southwestastrofair.com](http://www.southwestastrofair.com)  
Equinox Star Party, Kelling Heath, Norfolk 11-13th  
September - [www.starparty.org.uk](http://www.starparty.org.uk)

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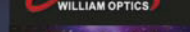
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# JON CULSHAW'S EXOPLANET EXCURSIONS

Jon retakes the helm of the Cruiser Globe, and almost immediately wishes he hadn't

I'M COMPELLED TO journey to Kepler 70, a star immensely more elderly than our Sun, having gone through its red giant phase a staggering 18.4 million years ago. It has become a B-type subdwarf star and sits 3,849 lightyears away in the most elegant constellation of Cygnus. Such a frail old star in such a graceful constellation brings to mind a grand old actress having retired to Harrogate, drinking sherry and having a contented twilight time.

In a close orbit around the star are two planets, Kepler 70b and 70c. The first completes an orbit in a dizzying 5.8 hours, as it is just 0.006 AU away from its host star. Perhaps it was similar to Jupiter in the days before its parent star expanded into a red giant – a process that would have blasted its gaseous layers away – but all that's left now is a molten core.

The second is my destination. Planet 70c sits in a more habitable area, whose orbit occasionally brings it very close to its neighbour at just 240,000km or so. It will be wonderful to observe celestial clockwork of such graceful enormity.

The elderly star Kepler 70 evokes a nostalgic feeling and so I'm making our excursion in my old ship, the trusty Cruiser Globe. It's the interstellar

equivalent of popping a picnic hamper in the back of the Cortina and heading to the countryside.

But alarmingly, there's a problem: the coordinate programmers of the old Cruiser Globe are failing! Perhaps it's the powerful magnetic activity streaming from star: the Cruiser Globe has lost its entire ability to place voyage coordinates with any degree of accuracy! Having overshot my intended location, I'm now at the mercy of the gravity of planet 70b, which is a pure vision of hell.

The Cruiser Globe has been locked into orbit around the planet, amid streams of noxious vapours burning off from the molten surface. More worryingly, the orbit the ship is caught in is decaying, and unless I act with the greatest urgency, my fate will be like the disturbing scene in the 1965 film *She*, in which Ursula Andress acquaints some unfortunates with a lava pit.

All I can do is hammer a few buttons on board the Cruiser Globe coordinate programmers, if my senses can deal with the paralysing heat and lacerating stench. I can but crudely aim for 'Solar System' and hope for the best. Switching

the controls off and then on again, there's a lurching surge like the downward plunge of a rollercoaster.

Forty-three disorientating, punishing minutes later, there's a noticeable calming, and the Cruiser Globe, in a final gasp of working properly, delivers on its promise of 'Solar System'. As the ship creaks and limps into safer regions, how beautifully familiar Pluto and Charon look as they reassuringly loom into view. It is an emotional homecoming!

Once, over in a Greenwich pub, *The Sky at Night* co-presenter Chris Lintott commented, "You only ever encounter awesome spectacle on your *Exoplanet Excursions*. You never have a terrible time do you?" Well, Professor Lintott, I hope you're satisfied!

Jon Culshaw is a comedian, impressionist and guest on *The Sky at Night*

## This month's top prize: four Philip's books

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Heather Couper and Nigel Henbest's *Stargazing 2015*, Patrick Moore's *The Night Sky*, Storm Dunlop's *Practical Astronomy*, and *Stargazing with Binoculars* by Robin Scagell and David Frydman.

## PHILIP'S



## SOCIAL MEDIA

### WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

Have your say at [twitter.com/skyatnightmag](https://twitter.com/skyatnightmag) and [facebook.com/skyatnightmagazine](https://facebook.com/skyatnightmagazine)

@skyatnightmag asked: What is your greatest astronomy achievement to date?

@Johnimus\_Prime  
A\* result in my Astronomy GCSE this year!

@DavidBflower Earlier this year I captured three planets and the Moon in one picture.

**Andy Sawers** At the age of 54, studying at Royal Observatory Greenwich with my teenage daughter for a GCSE in Astronomy.

@MikeMcBride61  
Completing the Messier list after a 30-year hiatus that started when I was 18.

# Interactive

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## MESSAGE OF THE MONTH

### A transatlantic astronomical network arises

I am a member of East Sussex Astronomical Society (ESAS) and in July we joined forces with the North East Florida Astronomical Society (NEFAS), in much the same way that towns across the world become twins. The story started with me joining NEFAS and talking to their members online to discuss ideas for public astronomy events. Then, in November 2014 I was lucky enough to go out to Florida and meet the friendly people of NEFAS and it was then that the idea of twinning was born. We were able to return the favour when two NEFAS members came to the UK.

The idea of twinning our societies gained more momentum in July when Chris Lintott became our patron, replacing the much-missed Sir Patrick Moore. On the night of Chris's visit we linked up to NEFAS in Florida over Skype; they were able to watch his talk and take part in the question and answer session afterwards. Everyone on both sides of the Atlantic had a great evening (or afternoon, as it was in Florida).

Since then we have all become honorary members of each others' societies and have the Skype link open at both societies' meetings. This link between like-minded people across the world has been great for exchanging information, making new friends and putting a different perspective on the day to day running of a society. Several members of ESAS are going out to Jacksonville, Florida in October to attend a NEFAS meeting and help with an outreach event to wave the flag for UK astronomy.

My hope is that although we think we are the first society ever to do this sort of thing, many other societies will jump on the idea and create a network of connected societies around the world!

**Paul Foster, Vice Chairman, East Sussex Astronomical Society**

*What a fantastic idea, Paul. Credit to all at both societies for the drive to set such an innovative connection up. I hope you get a lot out of it! – Ed*



▲ Paul Foster, fourth from left, and members of ESAS after a talk by reviews editor Paul Money



▲ Members of NEFAS set up for an evening of outreach astronomy in Jacksonville, Florida

## An astronomer's ode

This is a little poem I penned a few years ago while waiting for skies to clear.

Jupiter's shining in the late summer sky,  
An almost full Moon emerges close by,  
Vega glows blue in the darkness above,  
The great Double Cluster is one we all love.

Andromeda's mistiness teases the eye,  
A meteor darts across darkening skies,  
The clouds fade away giving me hope,  
It looks like it's time to set up the scope.

Warm jacket and boots, red torch at the ready,  
Check your kit's cold, and tripod is steady,  
With batteries charged, eyepieces looked out,  
"Turn the damn lights off," I hear someone shout.

With these little thoughts, your hobby will grow,  
And empty your pockets of any spare dough,  
Endless late nights, and stinging red eyes,  
Stargazers never tire of watching dark skies.

**David Millar, Abernethy, Perth & Kinross**

*Delightful David – all the romance and frankness of Robbie Burns himself! – Ed*

## SOCIAL MEDIA

### WHAT YOU'VE BEEN SAYING ON TWITTER AND FACEBOOK

**@deepskymike** I once showed Darth Vader aka Dave Prowse around the Universe when he visited @WYAS\_73 (West Yorkshire Astronomical Society). Just me, him and an 18-inch reflector.

**@ThomasCurran151** Finding Uranus in my Dobsonian! It took me forever!

**Paul Shiels** Spending many nights trying to find Uranus. Checking what seemed like hundreds of stars until finally, a planet! Woke my poor wife up to tell her!

**@AndCoopes** Mine would have to be finding what I'm actually looking for with my non motorised telescope, and my Moon pics...

**@ParrGordonparr** Finding the Andromeda Galaxy among all the nearby trees.

**@Alpha\_lyrae\_uk** Observing quasar 3C 273 after spending quite some time eliminating field stars with a detailed star chart.

**@ND\_Martin** Finally managing to get the perfect conditions to capture M42 through my telescope on old-fashioned film.

**@sjb\_astro** Appearing on *The Sky at Night* for completing the Moore Winter Marathon. It was great to meet the team.

**@AstroExeter** Doing astronomy outreach work with thousands of people who never before 'looked up'.

## A future Pluto pioneer



▲ Jacob is captivated by images of Pluto – we wonder what he'll make of it not being a planet?

I am writing today on behalf of my seven-month-old, Jacob. Like his Dad he is fascinated by the Universe and everything in it, including NASA's New Horizons mission. He has a star map projector in his bedroom and soon a picture of Pluto to keep him amused.

In this picture he is enjoying his nightly bedtime story, which was read out by the New Horizons media team. He was massively intrigued and was kicking his legs when the image of Pluto came onto the screen. I am hopeful this is the start of bigger things to come for his future; first man to walk on Pluto maybe?

**James Parker, Northamptonshire**

*What budding astronaut could ask for a better start to life? Keep up the good work, James. – Ed*

## Is Jupiter a planet?

I have read with great interest the excellent article on Pluto in your August edition, ('The Story of Pluto', page 63). At the end of the article there is, as you state, the emotive question of whether or not Pluto should be a planet. I have tried to understand the definition, and can only conclude that the IAU was rather hasty in setting the parameters for planetary status.

You're right to point out that both Earth and Jupiter fail the third condition of not having cleared their orbits, but neither does Neptune with Pluto crossing its orbit, nor Mars, which has many asteroids crossing its orbit.

Moreover, the largest 'planet' in our Solar System also fails on the first condition – that a planet has to orbit the Sun. Due to the mass of Jupiter and its distance from the Sun, the barycentre for the Sun-Jupiter system is actually outside the Sun. Jupiter does in fact not orbit the Sun but a common point in space, which the Sun also orbits! Just as Pluto and Charon have a barycentre outside Pluto and should be classed as a binary pair, Jupiter and the Sun are a binary pair not a star and planet.

The second condition, that a planet has to assume hydrostatic equilibrium (a nearly round shape), lacks definition; what is a nearly round shape anyway? Jupiter is not a nearly round shape but more of a very oblate spheroid, due to the speed of its rotation, with an equatorial diameter much greater than its polar diameter.

It seems that the largest 'planet' in our Solar System fails on all three conditions, but would the IAU ever dream of demoting Jupiter to any status

other than planet? I doubt that very much, and such a decision would be ludicrous anyway. The IAU should go back to the drawing board and develop a better definition of what a planet is; if this means we decrease or increase the number of official planets in our Solar System this should not matter. What should matter is that it is the correct definition and one that can be applied across the board.

**Paul Campbell, Chair of Wakefield and District Astronomical Society**

*A fascinating insight, Paul, thank you. The IAU says there are no formal requests from anyone in the astronomical community to re-evaluate the definition at present, though it notes that there is a well-defined process for doing this through the Resolutions presented at each IAU General Assembly. – Ed*

## My growing addiction



▲ Paul's increasingly complex DIY DSLR mount; up next: a home-made refractor?

Having been inspired by the many *How To* articles in *BBC Sky At Night Magazine*, I started to build a mount for my DSLR, which included a stepper motor and an Arduino computer so that it could track the night sky. I finished this, but found that I was addicted.

I then added tracking to the

Right Ascension axis, and attached an Orion Mini Guider and, using the excellent guidance on the Ascom website (<http://ascom-standards.org>), I was able to build my own device driver. I found that with the PHD2 guiding software (<http://openphdguiding.org>) I could easily connect to the Orion Guider and my mount using USB connections.

Next step was to add a similar mechanism for declination, which involved another stepper motor and Arduino, plus an extension to the device driver software so both Arduinos could communicate. I'm currently contemplating replacing the telephoto lens with a refractor... I said I was addicted!

**Paul Julier, via email**

*Well done Paul, what a hugely impressive construction. Let us know when you've completed the automated observatory with cloud sensor-driven roll-off roof! – Ed*

### OOPS!

• In September's *How To* about studying sudden ionospheric disturbances (page 81), the units of the vertical axis of the graph (Signal strength) should have been millivolts, or mV.

BBC

# Sky at Night

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MAGAZINE

# Hotshots

This month's pick of your very best astrophotos



## ▲ The Rosette Nebula

JONATHAN BLAKE, ANDOVER, 22 FEBRUARY 2015

**Jonathan says:** "The Rosette Nebula can be found close to Orion between Betelgeuse and Procyon. It has the open cluster NGC 2244 at its centre. This image was combined with the Hubble palette in Photoshop using the excellent Annie's Astro Actions plug-in. I am stunned and delighted with the result. It is amazing that amateurs like myself can produce fantastic images just from our own back gardens."

**Equipment:** Starlight Xpress Trius-SX694 CCD camera, William Optics GT-81 apo triplet refractor, HEQ5 mount.

**BBC Sky at Night Magazine says:** "Astronomy aside, this is a beautiful image with amazing colour composition. The brightness and warmth of the image has captured the energy and activity of the star-forming region. It's a fantastic photographic achievement."

**About Jonathan:** "I became interested in astronomy after the Moon landing in 1969 and bought a 14-inch Dobsonian in the mid 1980s. Over the past three years I have invested in my equipment, a recent addition being an 8-inch Ritchey-Chrétien for capturing galaxies and planetary nebulae."





## ◀ The Milky Way

DYLAN WALTON, CHARMOUTH, 29 JULY 2015

**Dylan says:** "The sky was so dark the night I took this you could see the Milky Way with the naked eye. I couldn't resist capturing its beauty to share with my friends and family at home in Birmingham."

**Equipment used:** Canon EOS 350D DSLR camera, piggybacked on a Sky-Watcher Explorer-150P reflector, Sky-Watcher EQ2-3 mount.



## ▲ Blue Moon

LEE TILLEY, HOUNSLOW, 1 AUGUST 2015

**Lee says:** "This shot of the blue Moon was only my second or third attempt at lunar photography with my new Canon SX60. I'm extremely happy as I live next to Heathrow Airport, so astrophotography is a tall order with the light pollution."

**Equipment used:** Canon Powershot SX60 HS digital compact camera.

## ▼ Elephant's Trunk Nebula

TREVOR NICHOLLS, CHELMSFORD, 22 JULY 2015

**Trevor says:** "The Elephant's Trunk is a concentration of interstellar gas and dust within the larger ionised gas region of IC 1396 in the constellation of Cepheus."

**Equipment used:** QSI 6120 CCD camera, Takahashi FSQ-106ED refractor with QE reducer, Paramount MX mount, Astrodon 5nm narrowband filter.



## ▲ The Crescent Nebula

CHRIS HEAPY, MACCLESFIELD, 16 JULY 2015

**Chris says:** "NGC 6888 is a crescent-shaped nebula located towards the centre of Cygnus. It is a remarkable object formed by a hot Wolf-Rayet star throwing off its outer layers."

**Equipment:** Atik 490EX CCD camera, Tele Vue NP127is apo refractor, Losmandy G11 mount, guided with a Tele Vue Pronto and Starlight Xpress Lodestar autoguider.



## ◀ The Andromeda Galaxy

MARIUSZ SZYMASZEK, CRAWLEY, 23 JULY 2015

### Mariusz says:

"Over the past two or three years I have attempted to capture the Andromeda Galaxy a few times. Recently I changed my mount and scope, and I have to say I'm very happy with the result."

**Equipment:** Pentax K-5 DSLR camera, Sky-Watcher Evostar 80ED DS-Pro refractor, Sky-Watcher HEQ5 Pro GoTo mount.

## ▼ Spiral galaxy M106

RICHARD WYKES, NORTHAMPTONSHIRE, 30 JULY 2015

**Richard says:** "On the night I took this, the skies were kind to us. I enjoy everything space-related but do have a soft spot for galaxies, so I was pleased to have captured some fainter ones in the background too."

**Equipment:** Canon EOS 1000D camera, Sky-Watcher 250P 10-inch Newtonian reflector, Sky-Watcher NEQ6 mount, guided with a Sky-Watcher ST80 refractor and QHY5L-II CCD camera.



## ▲ The Lagoon and Trifid Nebulae

CHRISTIAN VAN DEN BERGE, KIRIPOTIB, NAMIBIA, 16 JULY 2015

**Christian says:** "This is the very colourful and interesting region of M20 and M8 with its distinct dark clouds, reflection nebulae and star clusters."

**Equipment:** Nikon D600 DSLR camera, APM 107-700 apo refractor, Riccardi 0.75x reducer, Fornax 51 mount, Lacerta MGEN autoguider.



## ENTER TO WIN A PRIZE!

ALTAIR ASTRO

We've joined forces with Altair Astro UK to offer the person behind next month's best *Hotshots* image a fantastic prize. The winner will receive a GP-CAM 120C, 1.2mp colour HD astro camera for Solar System imaging of the Moon, Sun, and planets. [www.altairastro.com](http://www.altairastro.com) • 01263 731505




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# Dark sky at night, stargazer's delight

**See the wonders of the universe at the UK's first dark sky park.**

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**[www.forestry.gov.uk/darkskygalloway](http://www.forestry.gov.uk/darkskygalloway)**

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# THE DARK SKIES SURVIVAL GUIDE

The view of the stars from a site with dark skies is truly breathtaking. These tips from **Paul Money** will stop you from becoming overawed as you take your first steps in astronomy

**D**ark skies can be a little daunting if you've not experienced them before. Away from the orange haze of light pollution above the urban areas where most of us live, the night sky is ablaze with stars. While you can see perhaps 600 from a suburban location, under really dark rural skies that

number jumps up by a factor of 10 to around 6,000. Faced with such an intensely starry scene, it is easy to get lost in the sheer scale of it. This guide will help you to get the most out of the experience if you are just starting out; its simple steps will set you on the way to stargazing like a seasoned pro in no time!



#### ABOUT THE WRITER

Paul Money is our reviews editor and a recipient of the Sir Arthur Clarke Lifetime Achievement Award for his efforts to promote astronomy.

Dark skies can reveal many more night-sky sights than you can see under the oppressive haze of light pollution



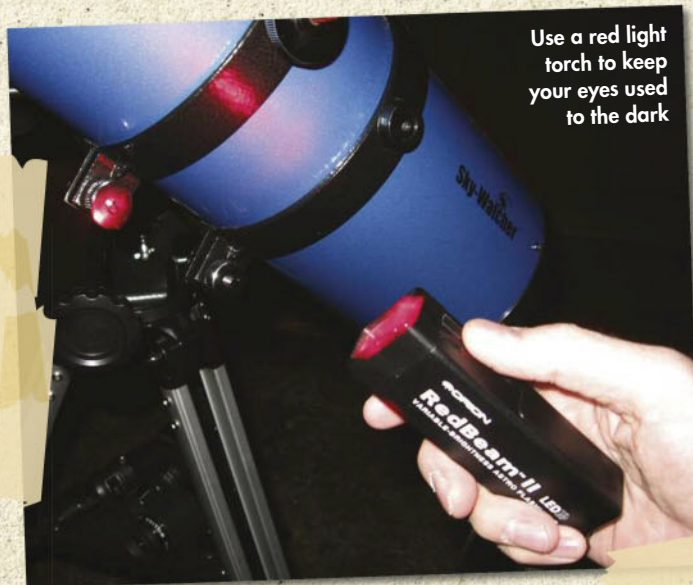
## ◁ Choose a good observing site

The first thing to consider if you're out for some stargazing is your location: get to the darkest place you can find where large swathes of sky are visible. There are some bright objects in the night sky – the Moon, some of the planets, and a few dozen stars – but there are many more that artificial light washes out. A clear horizon all round is ideal, but if this isn't practical aim for an uncluttered southern view. Stars and planets rise in the east, set in the west and reach their highest each night in the south, so with a good southern horizon you'll see most things. For help finding a dark sky sight near you, visit [www.darkskydiscovery.org.uk](http://www.darkskydiscovery.org.uk).

## ▽ Stay comfortable and warm, whatever the weather

Next, wrap up warm, and not just in winter – it can get surprisingly chilly under a clear sky even in summer. Wear loose fitting layers to trap the heat more effectively and remember your hat and gloves as you can lose a lot of heat from your head and hands. A flask of hot soup and some sandwiches are useful for long observing sessions, while a fold-out seat or better still a sunlounger (should that be starlounger?) provides an extra level of comfort.

◀ Layer up before you head outside – even in summer the nights can turn quickly

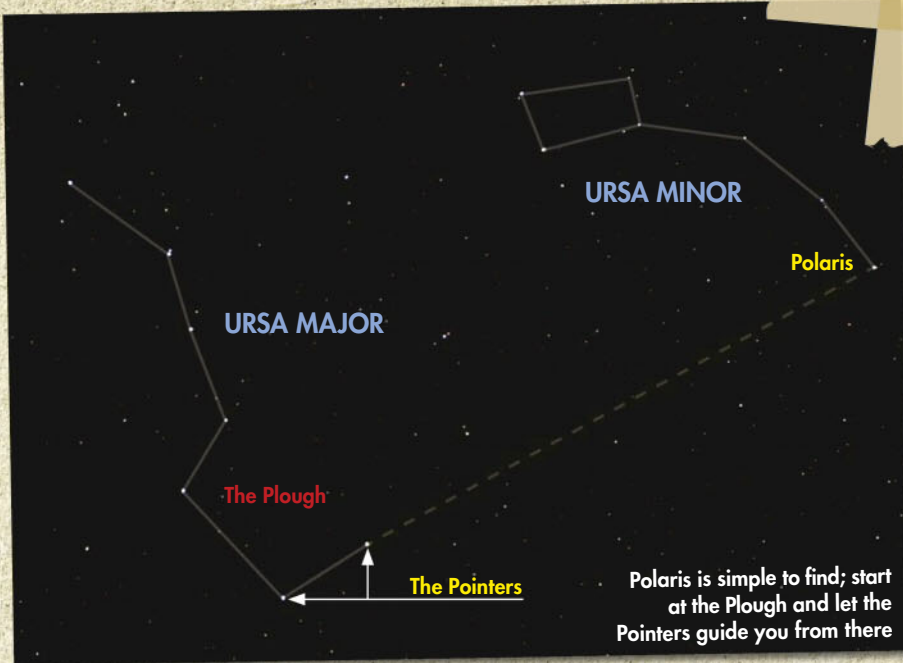


Use a red light torch to keep your eyes used to the dark

## △ Get used to the night sky

One thing that is often forgotten is that you'll get a much improved view if you give your eyes a chance to get used to the dark. It takes up to 40 minutes to completely adjust to the darkness, as the diameter of your pupils expands up to 7mm to allow more faint light to pass through to the retina.

If you go outside from a brightly lit room you won't see many stars at first, even if you are in an area with recognised dark skies, so sit back and let the spectacle reveal itself. Once your eyes are dark adapted, use a dimmable red light torch instead of a bright white one to keep them that way.



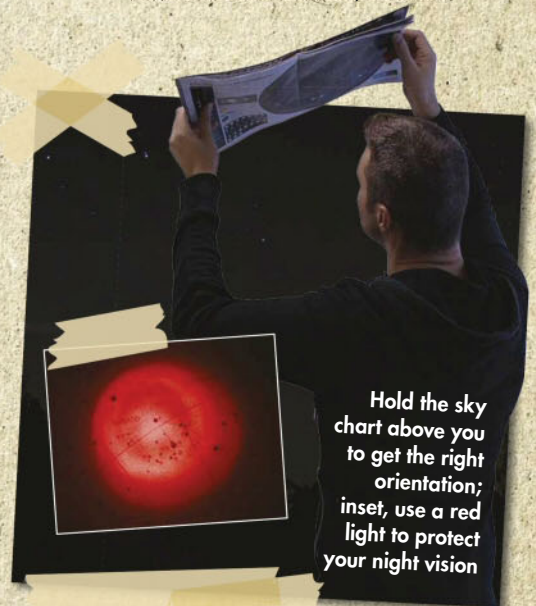
## ◁ Where should you start?

Looking at the night sky can be confusing. Random points of light appear on a dark background, and over a few hours these points will have changed position. The sky seems different because Earth is rotating, but the patterns made by the stars stay the same relative to each other. This means that if you know just one shape in the sky, you can find the rest. The best one to use as a guide is the Plough: it's large, bright, visible year-round in the north and has a familiar saucepan shape. The two stars that make up the side of the saucepan furthest from its handle also point to Polaris, the North or Pole Star; for this reason, they're called the Pointers. Polaris is positioned almost exactly above the Earth's axis at the North Pole, so unlike the rest of the sky it doesn't move and shows which way is north.

## Use a star chart ▷

With the monthly star chart in the centre of this magazine on pages 54 and 55, you'll be able to find a multitude of objects under a dark sky. It may look confusing at first: why, for example, is it the wrong way round, with west on the right and east on the left? Well, unlike most maps, this one shows what's above your head, not beneath your feet. Hold it above your head with the word 'north' pointing north and you'll find that east and

west are in the right place after all. To use it to look at things in different directions, hold it so that the bottom edge corresponds to the compass direction you are facing. It will then show the sky as it looks from that horizon and on up over your head. If you don't know which direction is which, use the Plough to find Polaris. Once you find north, the rest will follow. Use a red-light torch to view the chart in the dark – that way you won't ruin your night vision.

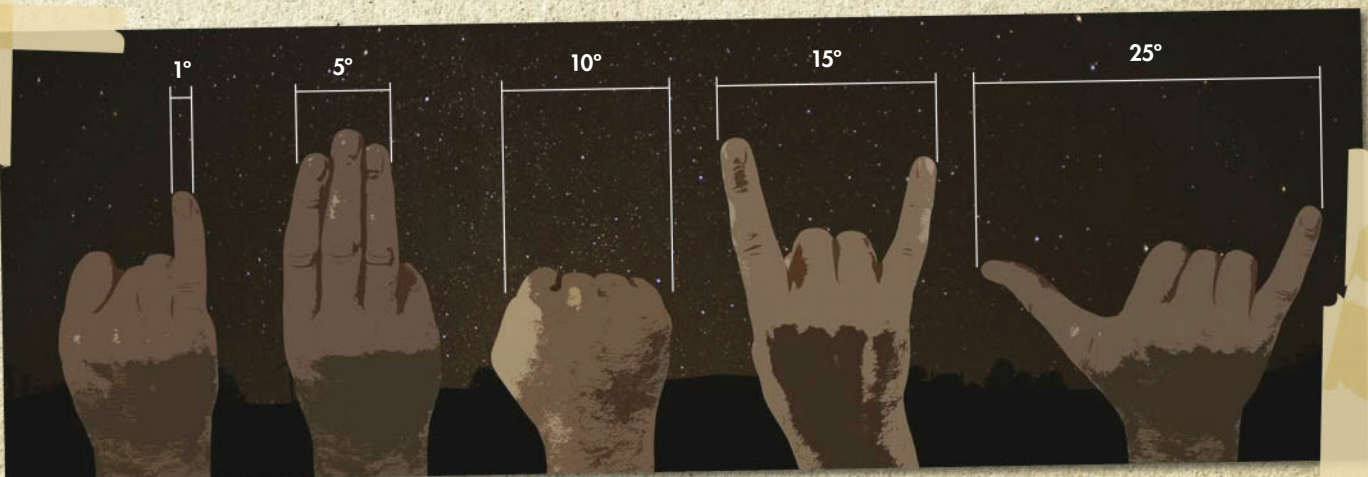


## ▽ Use your hands

Distances between objects in the night sky are measured in angles using degrees of arc, a bit like the angles of latitude and longitude on Earth's globe. One degree is equal to 1/360th of a circle. Conveniently, your fist

held at arm's length covers about 10° of the sky. Three fingers are about 5°, while your little finger covers 1°. If you want to find a dim object in the sky and a star chart shows that it is about 15° in a certain direction from a

brighter, known star, then you can use your outstretched hand as a ruler to measure off the distance on the night sky. Between the two Pointer stars of the Plough, for example, the distance is about 5°.



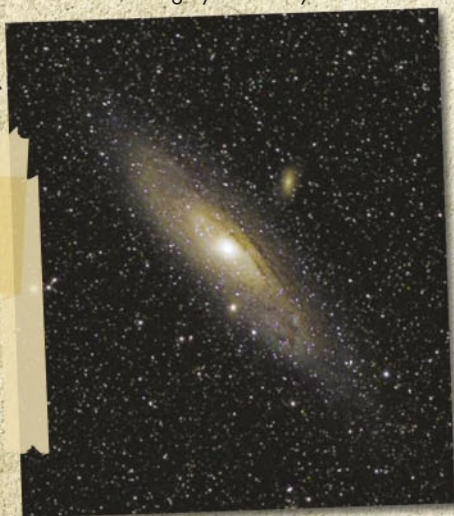
▲ These hand positions can help you to estimate distances between celestial objects – but remember to use them with your hand at arm's length

# ▽ Try a star hop

Star hopping is an easy way of finding dimmer objects, such as galaxies and star clusters, by using bright stars and the shapes of constellations as signposts to them. Below are three easy ones for you to have a go at.

## 1. OUR NEAREST GALAXY ►

From the Pointers head to Polaris (Alpha ( $\alpha$ ) Ursae Minoris), then follow that line until you reach the W-shaped constellation of Cassiopeia. Note the star Schedar (Alpha ( $\alpha$ ) Cassiopeiae). Extend a line from Polaris through this star. You will come to the Andromeda Galaxy, M31, just visible to the naked eye and estimated to be 2.5 million lightyears away.



▲ Obviously M31 won't look like this to the naked eye – you'll see more of a fuzzy patch



## ◀ 2. CITIES OF STARS

Find Cassiopeia from Polaris as in the previous star hop. Extend the line between Navi and Ruchbah (Gamma ( $\gamma$ ) and Delta ( $\delta$ ) Cassiopeiae) and continue in this direction towards the constellation of Perseus. Just over halfway to its brightest star, Mirphak (Alpha ( $\alpha$ ) Persei), you will discover a pair of star clusters close together – this is the wonderful Double Cluster.



▲ Unlike M31, you need optical aid to glimpse the Double Cluster – binoculars will do nicely



### 3. THE POLE STAR OF THE PAST ►

Starting at the Pole Star, Polaris, follow the next three brightest stars that form a curved line extending away from it – these being Delta ( $\delta$ ), Epsilon ( $\epsilon$ ) and Zeta ( $\zeta$ ) Ursae Minoris. This will bring you to a brighter orange star called Kochab (Beta ( $\beta$ ) Ursae Minoris). Extend this straight line and you'll come to Thuban (Alpha ( $\alpha$ ) Draconis). Only 5,000 years ago, during the time of the Pharaohs of Ancient Egypt, this was the Pole Star.



## ▽ Bring binoculars

The naked eye can show you a lot of wonders from a dark sky site, but with a pair of binoculars you will see many more thanks to their light-gathering and view-brightening abilities, as well as their modest magnification. Lighter binoculars such as 7x35s, 7x50s, 10x25s and 10x50s (the first number is the magnification, the second the diameter of the front lenses) aren't any trouble to hold by hand for a time before your arms start to wobble, but go any larger and it is well worth fitting them to a tripod with an L-shaped bracket for extra stability. A compass is useful to help you judge your viewing direction, and don't forget a red light torch to keep your dark adaptation while you consult the star chart that you've also brought along. Smartphone apps such as Redshift or SkySafari can also be useful – just make sure your phone's screen is covered with red acetate.



▲ Holding large binoculars by hand can leave you with incredible arm ache, which is where a mount like this one can come in handy



▲ The depth of the Universe awaits – all you have to do is seek out a dark sky (and perhaps cross your fingers for good weather)

## △ What you'll see

Your eyes and a pair of binoculars are enough to keep you busy for a lifetime. With your eyes alone, you can see meteors, noctilucent clouds, aurorae, an occasional bright comet, whole constellations, the brighter planets and the sky-crossing Milky Way – our own Galaxy. With binoculars you'll be able to see much more, from close-ups of craters and 'seas' on the Moon to bodies beyond the Solar System, to double and multiple stars, globular clusters, nebulae and galaxies. So it really is worth getting to know the star-speckled view from your nearest dark sky area. There's a whole Universe out there to explore.

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# 8 THE OCTOBER CTATHLON

**Will Gater** sets eight mini challenges for all abilities to highlight the great celestial sights on show this month

**W**ith the astronomy season now well and truly underway and the dark nights of autumn here once again, there's plenty to entertain us in October's night skies. We've decided to celebrate the fantastic range of celestial sights on show this month with a special set of eight mini challenges. If you're just starting out in the world of stargazing then you'll find lots here to inspire you to look up, while also learning some of the basic techniques of astronomical observing. If you're a more seasoned astronomer there's plenty to challenge you on the following few pages too, including several astro imaging projects that require skill and attention to detail to execute well. As always, we'd love to hear how you get on with the eight challenges, so be sure to send your images, sketches and observing reports to us at [inbox@skyatnightmagazine.com](mailto:inbox@skyatnightmagazine.com).



#### ABOUT THE WRITER

Will Gater (@willgater) is an astronomer and journalist. He is the author of several books and presents live astronomy shows for Slooh.

The faint smudge of the Andromeda Galaxy is best seen away from artificial lights

## CHALLENGE 1. SEE THE ANDROMEDA GALAXY UNAIDED

Glimpsing the Andromeda Galaxy, M31, with the naked eye is something of a rite of passage for every stargazer, and no matter how many times you have viewed it there's nothing quite like catching sight of it on a crisp autumn night. Mid October is an ideal time to seek it out as it'll be sitting high in the south around midnight.

Part of the fun of observing the galaxy with the naked eye is the realisation that you're looking at an object some 2.5 million lightyears away. In order to track it down you really need to get away from artificial lights and choose a night when the Moon isn't up. Also allow your eyes to adapt to the darkness for at least 30 minutes to an hour.

One of the easiest ways to find M31 is to begin at the bright star Hamal (Alpha Arietis). Imagine a line between it and bright Mirach (Beta Andromedae); this line is pointing in the rough direction of the galaxy. Extend the line by about 8° beyond Mirach and you should see a narrow oval of faint light – that's M31!

## CHALLENGE 2. CAPTURE A DSLR PLANETARY PORTRAIT ON 9 OCTOBER

We're lucky this month as 9 October sees a particularly beautiful grouping of the crescent Moon, Mars, Jupiter, Venus and even the bright star Regulus (Alpha Leonis) in the pre-dawn eastern sky. It's the perfect opportunity to practice some basic astrophotography techniques, so our second challenge is to capture a 'nightscape' image of this striking celestial gathering.

You'll need a clear view to the east. Probably the best time to shoot will be around 05:00 BST (04:00 UT), when the planets and the Moon are low enough that you can include some interesting foreground scenery. DSLRs and decent bridge cameras are ideal kit for this sort of astrophotography. You'll also need a tripod to support your camera. If you have

a remote release be sure to use it – if not, many cameras have a delayed shutter function that fires the shutter a few seconds after you press the button, so as not to blur your images. To capture the whole grouping over a horizon, a lens with a focal length of around 50mm for a full frame DSLR and around 24mm for an APS-C format camera will be ideal.

The challenge with this shot will not just be in creating an interesting composition with the foreground landscape, but also exposing the image enough to bring out the 'earthshine' on the Moon too. You may have to experiment with various different



▲ Regulus, Jupiter and Venus (left to right) appeared together on 9 June 2015. In October they'll be joined by a waning crescent moon (inset, with earthshine) and Mars

exposure lengths and ISO settings to get the balance between image sharpness and brightness just right.

## CHALLENGE 3. TAKE A BINOCULAR TOUR OF THE AUTUMN MILKY WAY 🕶️

The sight of the Milky Way on a crisp, clear autumn night is enough to set any stargazer's heart racing. To that end, our next challenge gets us wandering through the Galaxy's rich star fields with a pair of binoculars. See how many objects you can tick off!

Let's start over in the southwest sky after twilight has faded. The glorious summer Milky Way is still, just, on show low on the horizon. If you have a particularly clear line of sight in this direction look for the Lagoon Nebula, M8, lurking not far from the Teapot asterism's stubby 'spout'. Moving higher in the sky, through the northern part of Sagittarius and into Scutum, you'll come across the beautiful Scutum Star Cloud. Scan about  $11^\circ$  north from here and you'll also find two open clusters that sit side by side in a pair of 10x50 binoculars: IC 4756 and NGC 6633.

Yet further along the meandering star fields of the Galaxy sits the bright star Altair (Alpha Aquilae) and, next to it, the star Tarazed

(Gamma Aquilae). As you scan through the Milky Way you can use these two as a signpost to another great binocular object: the Coathanger Cluster. Imagine a line from Altair to Tarazed and head on a little over  $10^\circ$  more to find it. Once you've admired the Coathanger, scan across the constellation of Vulpecula and through Cygnus, looking out for the numerous open clusters – such as M39 – that are embedded in this wonderful part of the Milky Way.

From Cygnus we now head in the direction of Cassiopeia. In mid October it's high overhead at about midnight. Our favourite binocular sight in this region has to be the pairing of M103 and NGC 663. You'll spot them a little way from the bright star Ruchbah (Delta Cassiopeiae), with the star and both clusters easily fitting within the field of view of a pair of 15x70s. And of course while we're in this part of the sky we have to take a peek at the exquisite Double Cluster (NGC 869 and NGC 884) in neighbouring Perseus.



▲ To the eye the Milky Way is a majestic misty band, but a pair of binoculars will reveal the celestial gems sprinkled throughout

The final leg of our little binocular tour of the autumn Milky Way is a reward for the real night owls out there who are willing to stay up until the early hours: we're going to finish up in the constellation of Auriga with the open clusters M36, M37, and M38.

You'll find them scattered in the region between the stars Theta Aurigae and Elnath (Beta Tauri). The three clusters appear almost in line, with M38 at one end and M37 at the other, while M36 sits just over a third of the way between the two.

## CHALLENGE 4. SKETCH A GLOBULAR CLUSTER 🖋️

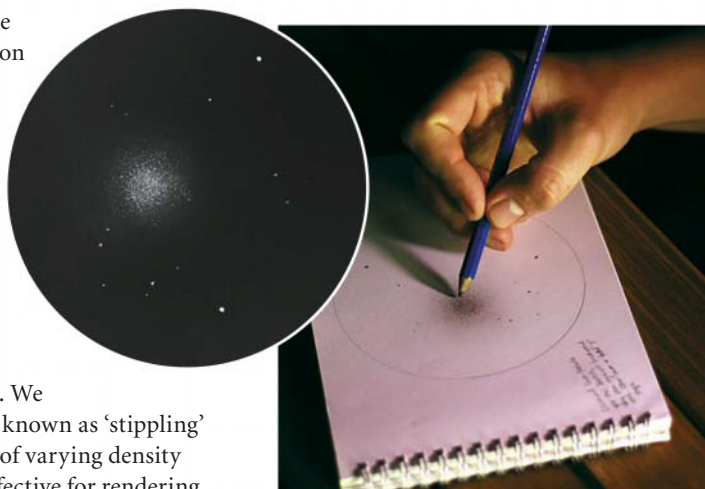
October's night skies are littered with globular clusters. These beautiful objects typically consist of thousands of stars packed together in a – relatively – tight 'ball'. Through a modest telescope a bright globular cluster is an awe-inspiring sight, but in this challenge we don't just want you to observe one – we want you to sketch it too.

The magnificent M13 in Hercules is an obvious choice if you're using a small telescope, but there are plenty others to choose from including M71 in Sagitta and M15 in Pegasus.

To start, draw a circle onto a clean sheet of paper or sketchpad to mark the edge of your scope's field of view. Then, at the eyepiece, take a few minutes to study the view carefully, noting the positions of the

brighter stars in the field and the location of the cluster relative to them. Then using a pencil – we used a combination of a 2H and a 3B – start marking the stars into your sketch.

Lastly it's time to draw the cluster. We find the technique known as 'stippling' – using small dots of varying density – is particularly effective for rendering globular clusters, though do try to portray the density, distribution and brightness of the cluster stars as accurately as possible.

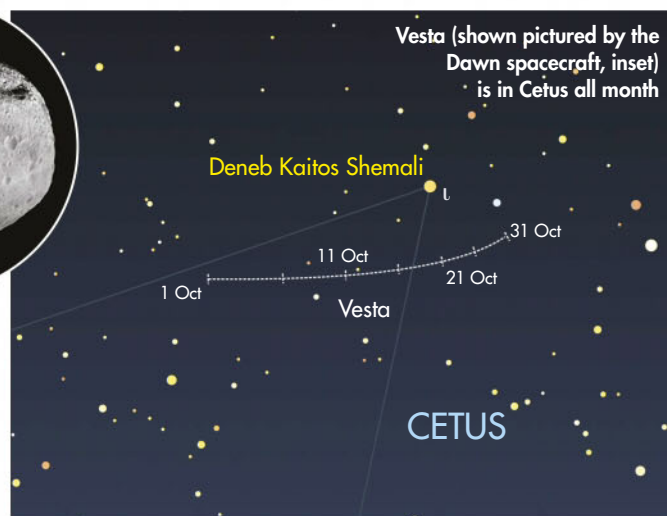


▲ After completing your sketch, why not scan it and invert the image to re-create the view through the eyepiece (inset)

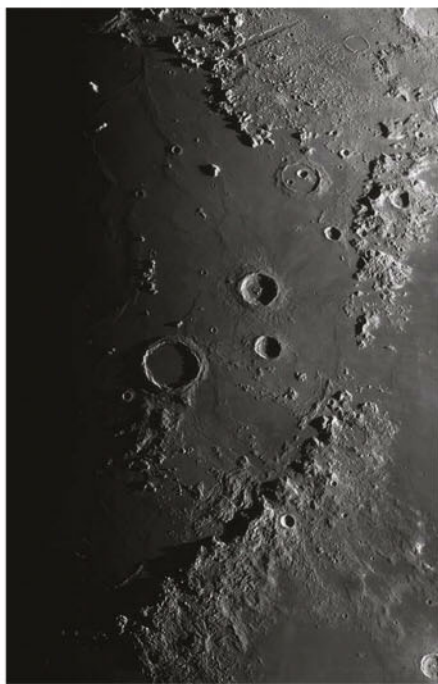
## CHALLENGE 5. TRACK DOWN A MINOR PLANET

In July 2011 NASA's Dawn probe went into orbit around the minor planet Vesta. The pictures it sent back showed a battered, potato-shaped world covered in craters of all different sizes. Vesta is actually visible in the night sky using amateur equipment and early October this year is a great time to go looking for it. So that's our next challenge: track down Vesta yourself with a good pair of binoculars or a small telescope.

Unfortunately in amateur kit the 525km-wide space rock appears as nothing more than a star-like point of light, but it's a fun one to tick off your observing list nevertheless. Towards the middle of the month it's visible in the south around midnight, not far from the star Deneb Kaitos Shemali (Iota Ceti). The star chart on the right will help you home in on its location as it moves across the constellation of Cetus night after night.



## CHALLENGE 6. MAKE A LUNAR MOSAIC



▲ The Montes Apenninus are a great imaging target when they are on the terminator

Our next challenge is to capture and process a multi-pane mosaic showing a large swathe of the lunar surface. This can be quite a large project, so here are some tips to getting the shot. We'll assume you're using a webcam or high frame rate planetary camera, but some of the techniques can still be applied to pictures captured afocally or with a DSLR.

Once you've set up your telescope and have it tracking the Moon, select which part of the surface you'd like to highlight in your mosaic. For a dramatic panorama,

### CREATING YOUR MOSAIC

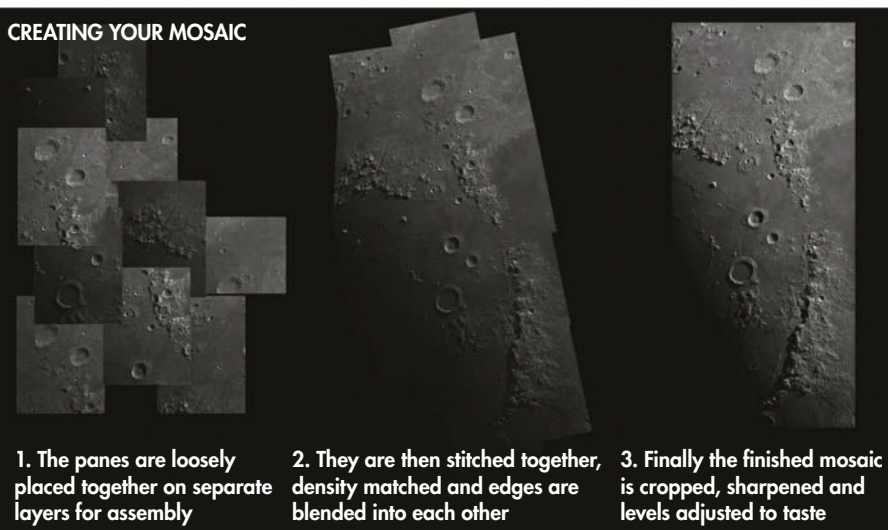


image a region close to the terminator on a night when many craters and mountain ranges are lit obliquely nearby; the latter half of October is good in this respect.

Next, focus the image and set the exposure. Try not to vary the exposure too much between panes as this can make the processing of a seamless mosaic later trickier; if this is your first attempt – and you're imaging around the terminator – find the brightest part of the surface that will feature in your mosaic, expose for that part and then don't change the exposure as you point the scope to image the different areas.

The next step is to capture the videos that will produce the individual panes in the mosaic. Carefully move the scope to image the different regions in your chosen composition, remembering to

leave a slight overlap between panes to guard against gaps in the final mosaic and to make blending them together easier. It's typically worth capturing a few thousand frames per video for each pane.

Now you need to process these videos in software such as RegiStax. Select, stack and wavelet sharpen the best few hundred frames before saving the resulting image.

Finally, bring all the still images into a layer-based editor such as Photoshop or GIMP. Arrange them all in separate layers and start to identify and overlay matching areas. To complete the mosaic, use the eraser tool to carefully blend the edges of overlapping panes before merging everything down. Lastly, you may like to crop and sharpen the image as well as give the 'Levels' of the final mosaic a tweak if necessary.



A driven mount is essential for the long exposures needed to image M33

## CHALLENGE 7. IMAGE M33 📷

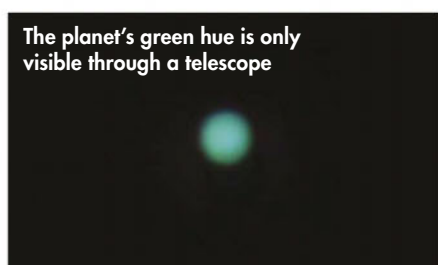
Like its neighbour the Andromeda Galaxy, the Triangulum Galaxy (M33) is a captivating observing target in October. Getting a really good image of it is a great test of any astrophotographer's skill too. So for this challenge we want to see your best shots of this distant galactic swirl.

You'll need a driven mount to track the sky during the long exposures necessary to pick up the galaxy. If you have a DSLR and a long focal length lens (say 200-300mm), try taking 10-15 one-minute exposures to produce a deep, wide-field image of it against the background stars; use software

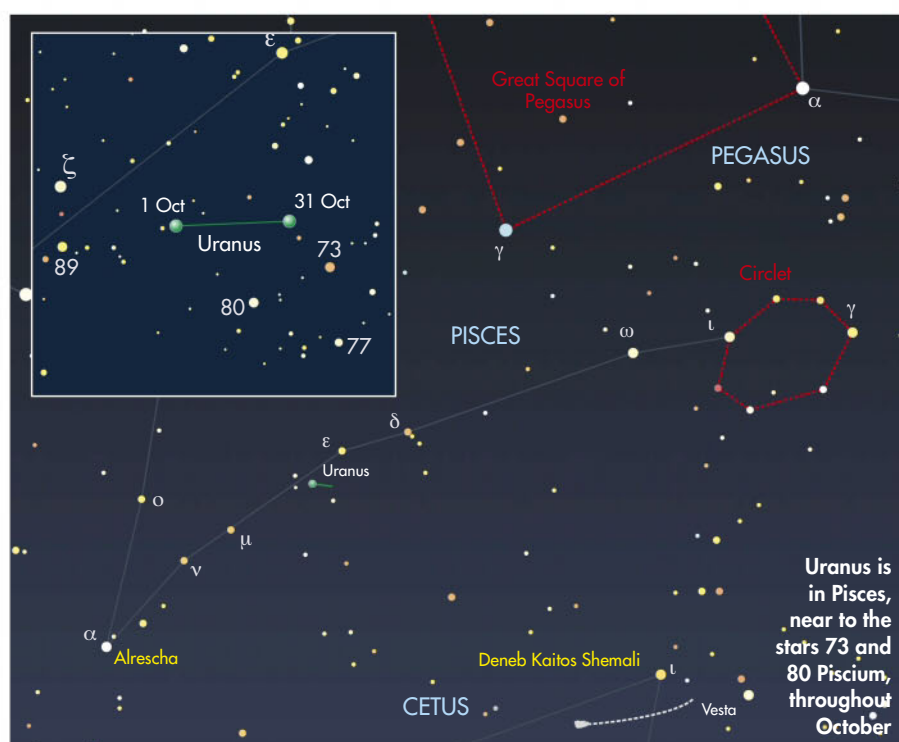
such as DeepSkyStacker to stack your images together. If you're already familiar with using a CCD camera and filters, we've an extra challenge: try to really bring out the pink star-forming regions in M33 by adding data captured using a hydrogen-alpha filter to your image.

## CHALLENGE 8. SEE THE DISC OF URANUS 🪐

The planet's green hue is only visible through a telescope



Our final challenge gets us tracking down a planet, the ice giant Uranus. It's currently in the constellation of Pisces, and at around mag.+6.0 it should be visible in a good pair of binoculars. For this challenge though we'd like you to get out your telescope if you have one – the bigger the better, as we want you to observe the tiny disc of the planet. At high magnification, with good seeing conditions, you should be able to see Uranus as a very small, faint and slightly green-blue disc. If you don't have a scope, pop along to your local astronomical society who may have one you can use. 📡



Uranus is in Pisces, near to the stars 73 and 80 Piscium, throughout October

# Meteorite

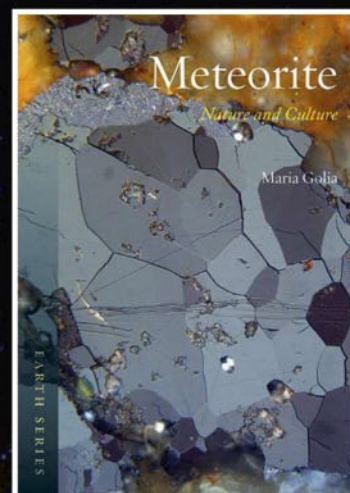
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# The Sky Guide October

Mercury, Venus, Mars, Jupiter and the Moon will all appear close together in the morning sky this month. A particular highlight of the meeting will be the apparent close approach of brilliant Venus and Jupiter on 24 and 25 October.



**Written by  
Pete Lawrence**

Pete Lawrence is an expert astronomer and astrophotographer with a particular interest in digital imaging. As well as writing *The Sky Guide*, he appears on *The Sky at Night* each month on BBC Four.

## DON'T MISS THE LUNAR ECLIPSE

Early in the morning of 28 September, the largest full Moon of the year undergoes a total lunar eclipse. The main umbral eclipse begins at 02:07 BST (01:07 UT), with the Moon in the south-southwest and 35° up from the centre of the UK. Greatest eclipse takes place at 03:47 BST (02:47 UT) with the Moon at 27° altitude in the southwest. The main eclipse ends with the dark umbral shadow moving off the lunar disc at 05:27 BST (04:27 UT). See last month's *Sky Guide* for full details.

**PLUS**

**Stephen Tonkin's  
BINOCULAR TOUR**  
Turn to page 58 for six  
of this month's best  
binocular sights

PETE LAWRENCE

# Highlights

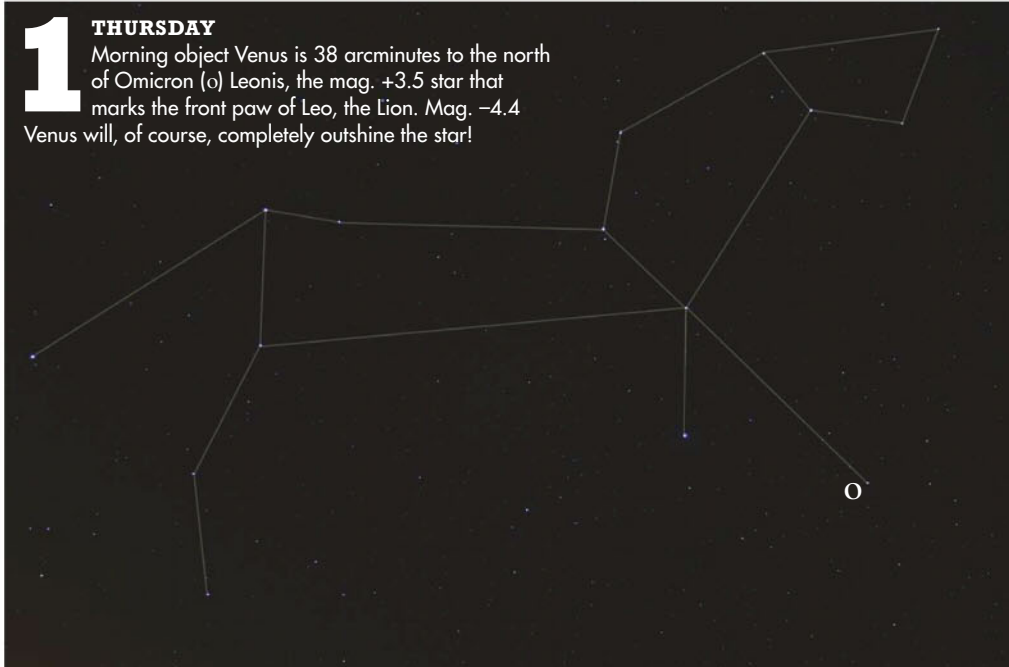
Your guide to the night sky this month



This icon indicates a good photo opportunity

## 1 THURSDAY

Morning object Venus is 38 arcminutes to the north of Omicron (o) Leonis, the mag. +3.5 star that marks the front paw of Leo, the Lion. Mag. -4.4 Venus will, of course, completely outshine the star!



## 3 SATURDAY



Minor planet Vesta reaches opposition in the constellation of Cetus, the Whale. At mag. +6.1, it's theoretically possible to catch sight of Vesta with the naked eye given a really clear and dark sky. However, using binoculars is the easiest way to spot it.

## 9 FRIDAY



Venus is 2.5° south of mag. +1.4 Regulus (Alpha (α) Leonis) in the morning sky. They form a neat triangle with the 12%-lit crescent Moon. After 04:30 BST (03:30 UT) the trio will be joined by Mars and Jupiter. A little after 06:00 BST (05:00 UT), Mercury joins the party.

## 12 MONDAY



Mag. +12.5 comet P/2010 V1 Ikeya-Murakami passes around 10 arcminutes to the north of mag. +1.9 Castor (Alpha (α) Geminorum) in the early hours. Castor rises at about 22:00 BST (21:00 UT) so by the morning of the 12th it will have attained a good altitude.

## 16 FRIDAY

The 12%-lit waxing crescent Moon lies 2.75° to the northeast of Saturn in the evening sky. Look for the pairing low in the southwest at around 19:00 BST (18:00 UT).

## 17 SATURDAY

If you're up in the early hours watching the fabulous collection of planets close together in the dawn twilight, don't forget that one of the best constellations in the entire sky, Orion, will be nicely placed at around 05:00 BST (04:00 UT).

## 18 SUNDAY



A close pairing of Mars and Jupiter can be seen in the early morning sky. The planets will be above the eastern horizon from 04:00 BST (03:00 UT), accompanied by brilliant Venus. Mars and Jupiter will be separated by around 23 arcminutes.

## 23 FRIDAY



Venus, Jupiter and Mars form a slightly kinked line in the morning sky, arranged from west to east in order of brightness.

An 80%-lit waxing gibbous Moon sits 2° above the planet Neptune in the early evening sky.

## 25 SUNDAY



The start of a really close encounter between Venus and Jupiter can be seen in the east around 03:00 UT. They will appear separated by 1.25°.

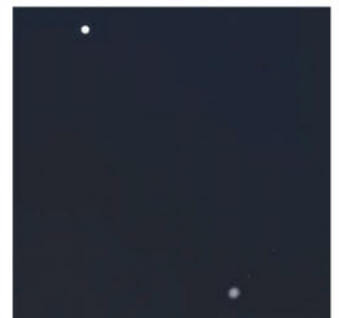
Daylight savings time ends for 2015 at 02:00 BST, when the clocks will revert back to 01:00 UT.

## 26 MONDAY



The close encounter between Venus and Jupiter climaxes with them separated by around 1° – look low in the east from 03:00 UT.

Uranus forms an equilateral triangle with the faint stars 80 and 73 Piscium.



## 29 THURSDAY



The 91%-lit waning gibbous Moon will appear to pass in front of mag. +0.9 Aldebaran (Alpha (α) Tauri) just after 21:45 UT. The star will remain hidden for about an hour before reappearing from behind the Moon's dark limb. See page 51.




## 30 FRIDAY




Mercury is a little under 4° north of mag. +1.0 Spica (Alpha (α) Virginis). This is a tricky spot low in the east-southeast just before sunrise. Mercury will be at mag. -0.9, so significantly brighter than Spica.

# 8 THURSDAY


 Look out for a 19%-lit waning crescent Moon off to the west of the brilliant planet Venus in the morning sky from about 03:30 BST (02:30 UT). Tomorrow morning, the 12%-lit Moon will be to the east of the planet and best seen from about 04:15 BST (03:15 UT).




# 10 SATURDAY

 The Solar System is really putting on a show now, with Mercury, a 6%-lit crescent Moon, Jupiter, Mars and Venus all in a slightly wobbly line in the morning sky. All five objects will be above the horizon together from just after 06:00 BST (05:00 UT).

# 11 SUNDAY

 As the Solar System show continues, look out for mag. +0.4 Mercury and a 2%-lit crescent Moon just over 2° apart, low down in the east around 06:00 BST (05:00 UT).

# 21 WEDNESDAY

 The annual Orionid meteor shower reaches its peak this evening. The shower is the result of Earth piling through the debris strewn around the orbit of Comet Halley. This year's display should be pretty good after midnight, when the 62%-lit waxing gibbous Moon has set. See page 51.



# 31 SATURDAY

 Mag. +1.7 Mars and -4.2 Venus will appear 1.5° apart this morning, heralding the start of a really close pairing of the two planets at the start of November. Look for them low in the east from 03:30 UT. The bright object above them is mag. -1.7 Jupiter.



## What the team will be observing in October



**Pete Lawrence** "All of those planets in the early morning sky will be hard to resist. I'll be out with my camera trying to assemble a composite to show their relative movement – try yourself with the imaging project on page 60."



**Paul Money** "I'll be trying to catch meteors both visually and with my camera, starting with the Draconids on the 9th and then the Orionids on the 21st. A new Moon on the 13th means Draconid conditions should be good."



**Chris Bramley** "With Uranus at opposition this month, I want to see if I can detect any colour visually. Finding it with my manual mount will bring real satisfaction!"

## Need to know

The terms and symbols used in *The Sky Guide*

### UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

### RA (RIGHT ASCENSION) AND DEC. (DECLINATION)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object lies on the celestial 'globe'.

### HOW TO TELL WHAT EQUIPMENT YOU'LL NEED



#### NAKED EYE

Allow 20 minutes for your eyes to become dark-adapted



#### BINOCULARS

10x50 recommended



#### PHOTO OPPORTUNITY

Use a CCD, planetary camera or standard DSLR



#### SMALL/MEDIUM SCOPE

Reflector/SCT under 6 inches, refractor under 4 inches



#### LARGE SCOPE

Reflector/SCT over 6 inches, refractor over 4 inches



## Getting started in astronomy

If you're new to astronomy, you'll find two essential reads on our website. Visit [http://bit.ly/10\\_Lessons](http://bit.ly/10_Lessons) for our 10-step guide to getting started and [http://bit.ly/First\\_Tel](http://bit.ly/First_Tel) for advice on choosing your first scope.

# DON'T MISS...

## 3 top sights

### 👁️ A planetary and lunar massing

**WHEN:** All month, as specified



The movement of Venus, Mars and Jupiter throughout October; for the location of Mercury, see page 52

THE OCTOBER MORNING sky will play host to five bright planets all rising at a steep angle with the eastern horizon. The net result should be a really dramatic planetary show.

On 1 October, mag.  $-4.4$  Venus appears first, popping above the east-northeast horizon around 03:15 BST (02:15 UT). It'll be quickly followed 15 minutes later by the bright, mag.  $+1.4$  star Regulus (Alpha ( $\alpha$ ) Leonis). The constellation of Leo forms the backdrop to this planetary gathering. Mag.  $+1.8$  Mars appears 20 minutes after Regulus followed by mag.  $-1.6$  Jupiter around 04:30 BST (03:30 UT).

Although the planets rise in the same order through the first week of October, the patterns they make slowly change

shape. By 8 October, a slender 18%-lit waning crescent Moon joins the scene west of Venus, itself now  $2.5^\circ$  south of Regulus. The Moon really crashes the party on the morning of the 9th, appearing as a slender 11%-lit waning crescent. Just after 06:00 BST, (05:00 UT) as the sky starts getting brighter, mag.  $+1.0$  Mercury also pops up in the east.

A 6%-lit waning crescent Moon lies below Jupiter on 10 October as it moves eastward towards Mercury. It finally catches up with the planet on 11 October, when its delicate 2%-lit crescent is just  $2.5^\circ$  west of Mercury's mag.  $+0.4$  dot.

Mars and Jupiter have a really close encounter from 16-20 October, both planets being less than  $1^\circ$  apart on



#### NEED TO KNOW

An object's brightness is given by its magnitude. The lower the number, the brighter the object: with the naked eye you can see down to mag.  $+6.0$ .

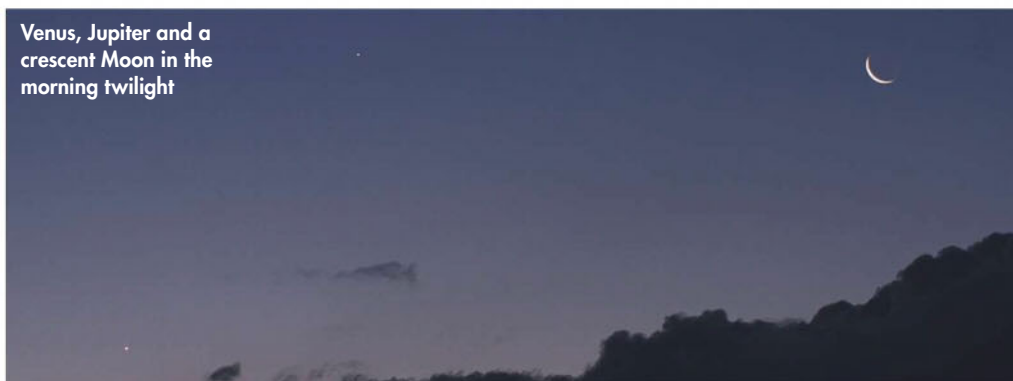
these mornings. On the morning of the 18th their apparent separation will shrink to a minimum of 23 arcminutes, approximately two-thirds the apparent diameter of the full Moon.

Mercury remains much closer to the eastern horizon after 06:00 BST (05:00 UT) over the next few days, but brightens too. On 21 October, it'll be mag.  $-0.8$  and sitting less than  $1^\circ$  below mag.  $+3.4$  Porrima (Gamma ( $\gamma$ ) Virginis).

Venus, Mars and Jupiter converge over this period and by 23 October, they will appear in a close, straight line formation with Mars to the east, Venus to the west and Jupiter in the middle.

The formation changes shape over the next few days and by 26 October, it'll appear as an isosceles triangle with Mars at the farthest end, while Jupiter and Venus form the narrow base, separated by around  $1^\circ$  on this date. All four planets continue to be visible right up until the end of the month. Mercury will become tricky as it gets closer to the Sun, but being at mag.  $-0.9$  it should be able to stand a fair bit of bright twilight.

Venus, Jupiter and a crescent Moon in the morning twilight



## October meteors

**WHEN:** All month, as specified

OCTOBER COULD PROVE to be an interesting month for meteor activity. The unpredictable Draconid shower peaks on the morning of 9 October, estimated to occur at around 06:40 BST (05:40 UT). This shower is normally rather weak, with a zenithal hourly rate of around 10-20 meteors per hour. However, occasionally outbursts occur, raising the faint meteor rates to around 500 per hour. No such activity is expected this year, but you can never rule it out completely. There's a new Moon on the 13th, making this year favourable for the Draconids in that respect.

The Orionid shower peaks on the night of 21/22 October. This is often a nice shower to observe despite its relatively low zenithal hourly rate of 25 meteors per hour. When you see an Orionid streaking across the sky, this is a tiny speck of Comet Halley vaporising in Earth's atmosphere. A 61%-lit waxing gibbous Moon conveniently sets around 00:45 BST on 22 October (23:45 UT on the 21st), leaving the rest of the night good and dark to enjoy the shower. Orionid meteors appear to emanate



from a region of the sky not far from Betelgeuse in Orion.

Finally, two Taurid showers return at the end of October and into November. Known as the Northern and Southern Taurids, these can produce interesting displays, again despite their relatively low zenithal hourly rates. Models of the Taurid showers suggest that there

could be enhanced activity towards the end of October through to about 10 November. The last time this occurred significantly was in 2005, when numerous Taurid fireballs were reported. The Moon is full on 27 October but new on 11 November, so it will pay to keep vigilant through to the start of next month.

## Aldebaran occultation

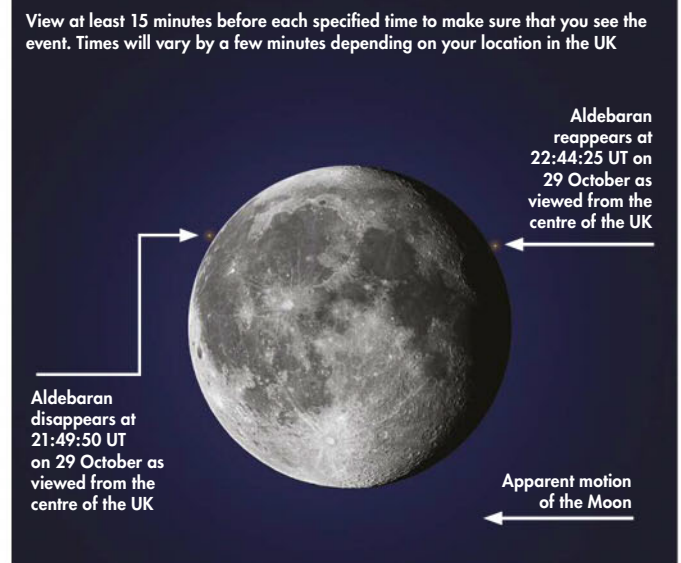
**WHEN:** 29 October, 21:30-23:00 UT

LAST MONTH WE reported that a series of occultations of the bright, mag. +0.9, star Aldebaran (Alpha ( $\alpha$ ) Tauri), had started to become visible from the UK. Last month's event occurred at the start of September in a bright dawn twilight sky; the reappearance occurred in daylight after the Sun had risen.

Another occultation happens on 2 October but in daylight and after the Moon and Aldebaran have set. However, on the 29th October, yet another lunar occultation of Aldebaran happens, and

this one is perfect for UK viewing. From the centre of the UK, the bright, leading edge of the Moon will mask the more distant star at 21:50 UT. Reappearance occurs from behind the Moon's dark, following limb almost an hour later, at 22:44 UT. As ever with lunar occultations, timings will vary with location, so we recommend grabbing a view of the Moon and star from 21:30 UT, just to be sure you don't miss anything.

If you want to get in the mood for the main event,



the Moon's disc will cover quite a few stars of the Hyades earlier in the evening. Catch the Moon rising around

18:40 UT and watch as it ploughs through the southern branch of this famous V-shaped cluster.

# The planets

## PICK OF THE MONTH

### MERCURY

**BEST TIME TO SEE:** 21 October

07:15 BST (06:15 UT)

**ALTITUDE:** 10°

**LOCATION:** Virgo

**DIRECTION:** East-southeast

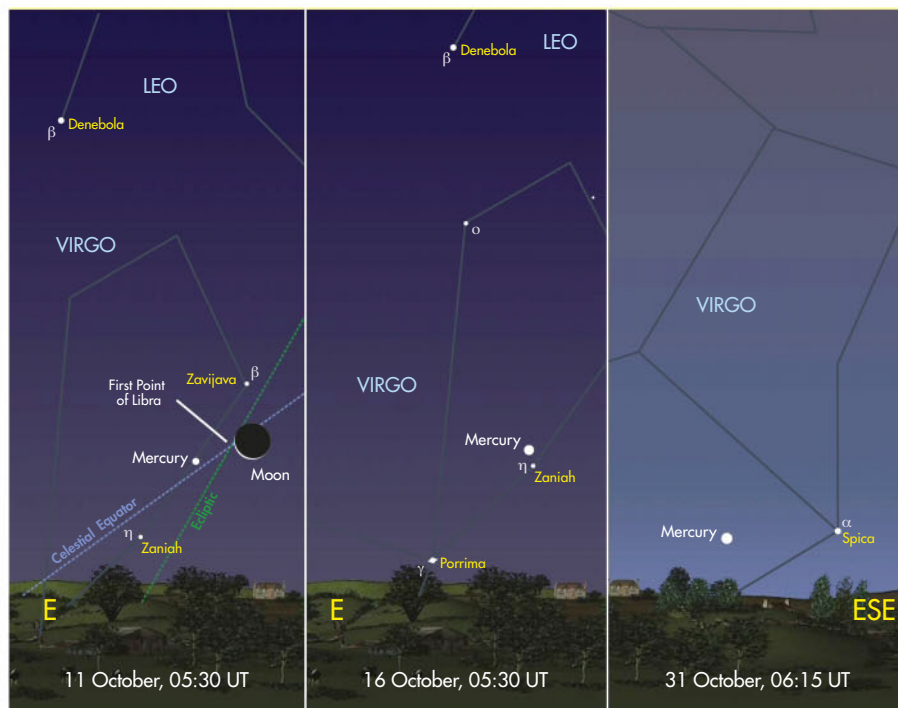
**FEATURES:** Phase, subtle surface markings

**EQUIPMENT:** 3-inch telescope for phase, 8-inch or larger for detail

MERCURY IS A morning object, initially visible around the start of the second week in October. After this it moves into position to give its best appearance of 2015, remaining in view for the rest of the month. On 8 October, the planet rises approximately 1.5 hours before the Sun, and appears as a mag. +1.4 dot low in the eastern dawn twilight.

As an aside, Mercury's position on 8 October is 1° east of the 'First Point' of Libra. This is the point in the sky where the centre of the Sun appears to cross the celestial equator moving from the northern to the southern celestial hemisphere. This is the instant in time that defines the northern hemisphere's autumn equinox, which occurred last month on 23 September.

Through a telescope on 8 October, Mercury appears as a 16%-lit, 8-arcsecond



The innermost planet has a series of close encounters through the length of October

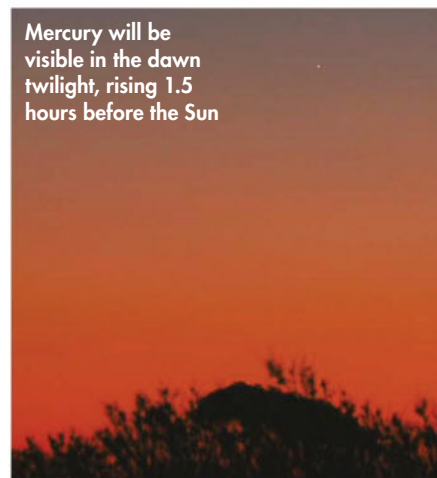
waxing crescent. Through the rest of the month, its phase increases as the apparent diameter slowly decreases. By 31 October, through the eyepiece Mercury will appear 92%-lit and just 5 arcseconds across.

Throughout this period, Mercury's brightness will increase. By 16 October, it'll appear at mag. -0.5, brightening slowly to -0.9 by the end of the month. Greatest western elongation occurs mid-month, on 15 October. On this date the planet will appear separated from the Sun by 18.1°.

Mercury makes a number of close passes to the stars of Virgo this month. On 16 October it is 40 arcminutes north of mag. +3.9 Zaniah (Eta (η) Virginis). On 21 October it is 50 arcminutes south

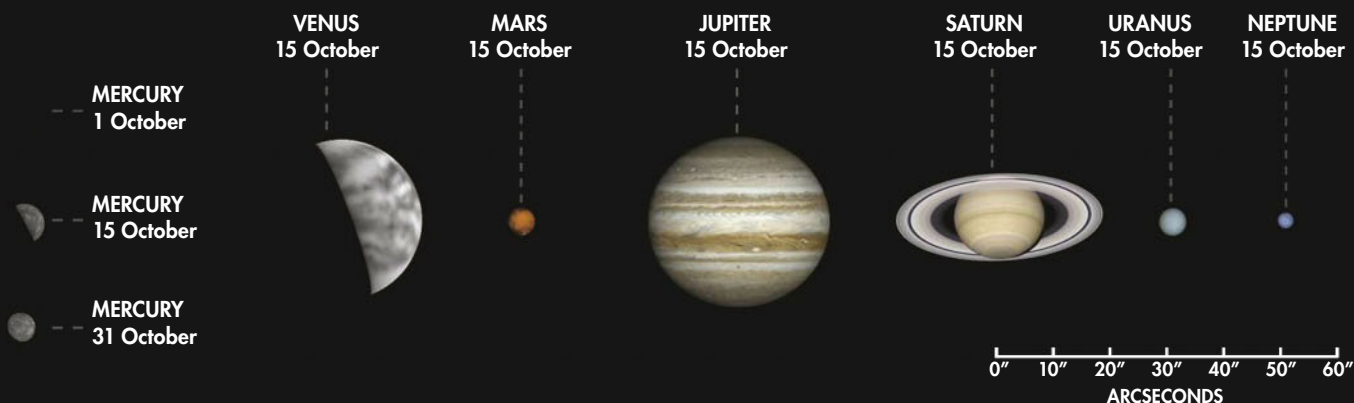
of the mag. +3.4 Porrima (Gamma (γ) Virginis) and on 31 October it is 4° north of mag. +1.0 Spica (Alpha (α) Virginis).

Mercury will be visible in the dawn twilight, rising 1.5 hours before the Sun



## THE PLANETS IN OCTOBER

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



## VENUS

### BEST TIME TO SEE:

25 October 05:30 UT

**ALTITUDE:** 27°

**LOCATION:** Leo

**DIRECTION:** East-southeast

Venus is a dominant planet in the morning sky. At the start of October it rises four hours before the Sun and manages to reach a decent altitude in dark skies; by month end it rises 4.5 hours before. Venus will have company through the month – check our guide on page 50 for details.

The planet begins October as a 35%-lit waxing crescent, 33 arcseconds across. Its phase will increase, reaching 50%-lit, or dichotomy, on the 26th. It's interesting to try and estimate when dichotomy occurs as it's normally late by a few days when Venus is in the morning sky. This is known as the Schröter effect. By the end of the month, Venus will present a 53% lit waxing gibbous phase, 23 arcseconds in diameter.

## JUPITER

### BEST TIME TO SEE:

31 October 05:30 UT

**ALTITUDE:** 28°

**LOCATION:** Leo

**DIRECTION:** East-southeast

Mag. -1.8 Jupiter is easily outshone by mag. -4.4 Venus in this morning sky, but still bright enough to outshine any night-time star. Its position is slowly but surely improving, and by the end of the month it manages to attain an altitude of 30° while the sky is still dark. Telescopically, the Jovian disc appears to increase in size throughout the month from 31 to 33 arcseconds and will show plenty of fine detail.

## URANUS

**BEST TIME TO SEE:** 12 October 01:00 BST (00:00 UT)

**ALTITUDE:** 43°

**LOCATION:** Pisces

**DIRECTION:** South

Uranus is at opposition on the 12th and visible all night long.

It shines on the limit of naked-eye visibility at mag. +5.7 and through a telescope its green-hued disc appears 3.7 arcseconds across. On 26 October, it forms an equilateral triangle with mag. +5.5 and +6.0 stars 80 and 73 Piscium.

## NEPTUNE

**BEST TIME TO SEE:** 12 October 23:00 BST (22:00 UT)

**ALTITUDE:** 28°

**LOCATION:** Aquarius

**DIRECTION:** South

Neptune remains well placed all month, reaching its highest point in the sky, due south, in darkness for the whole of October. On the 23rd, the 80%-lit Moon is 2° above mag. +7.8 Neptune in the early evening sky.

## MARS

**BEST TIME TO SEE:**

31 October 05:30 UT

**ALTITUDE:** 24°

**LOCATION:** Leo

**DIRECTION:** East-southeast

Mars is a morning object. It currently appears as an orange-hued mag. +1.8 star moving amongst the legs of Leo, the Lion, and is part of the impressive planetary line up in the pre-dawn sky.

Through a telescope, the Red Planet is a bit disappointing as it's a long way away from Earth. Its apparent diameter is 4 arcseconds all month, making it hard to pick out any significant detail.

## SATURN

**BEST TIME TO SEE:** 1 October 20:00 BST (19:00 UT)

**ALTITUDE:** 5° (very low)

**LOCATION:** Libra

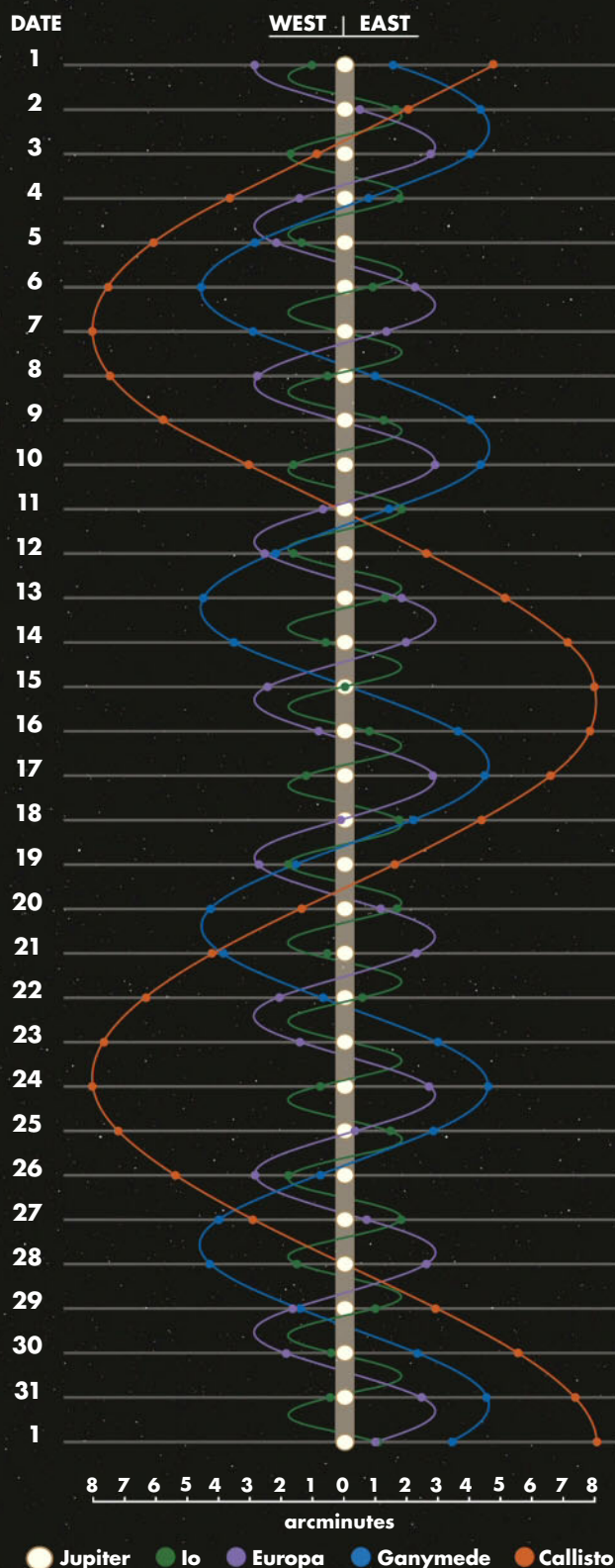
**DIRECTION:** Southwest

Mag. +0.6 Saturn is now too low for serious observation. It can still be seen with the naked eye or binoculars, low in the southwest after sunset. Look out for a 12%-lit waxing crescent Moon lying just less than 3° northeast of Saturn on 16 October.



# JUPITER'S MOONS October

Using a small scope you'll be able to spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date on the left represents 00:00 UT.



See what the planets look like through your telescope with the **field of view calculator** on our website at:

<http://www.skyatnightmagazine.com/astronomy-tools>

# The Northern Hemisphere

## KEY TO STAR CHARTS

- Arcturus** STAR NAME
- PERSEUS** CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM
- PLANET
- QUASAR
- STAR BRIGHTNESS:**
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW

MILKY WAY

## WHEN TO USE THIS CHART

1 OCTOBER AT 01:00 BST

15 OCTOBER AT 00:00 BST

31 OCTOBER AT 22:00 UT

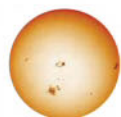
On other dates, stars will be in slightly different places due to Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

## HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.



## THE SUN IN OCTOBER\*



DATE	SUNRISE	SUNSET
1 Oct 2015	07:11 BST	18:47 BST
11 Oct 2015	07:29 BST	18:23 BST
21 Oct 2015	07:47 BST	18:01 BST
31 Oct 2015	07:06 UT	16:40 UT

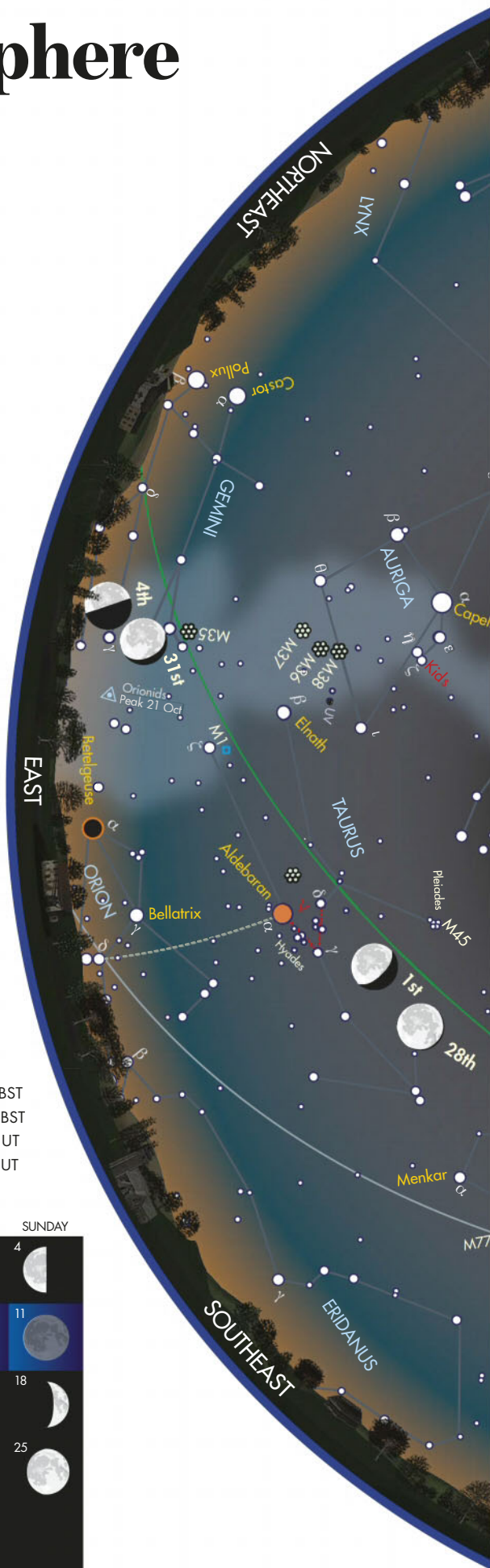
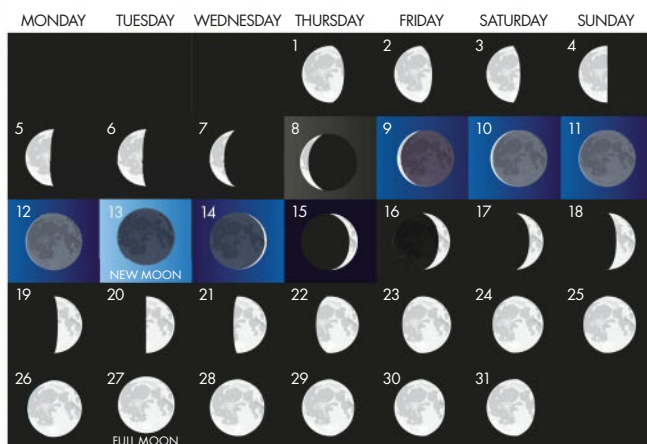
## THE MOON IN OCTOBER\*

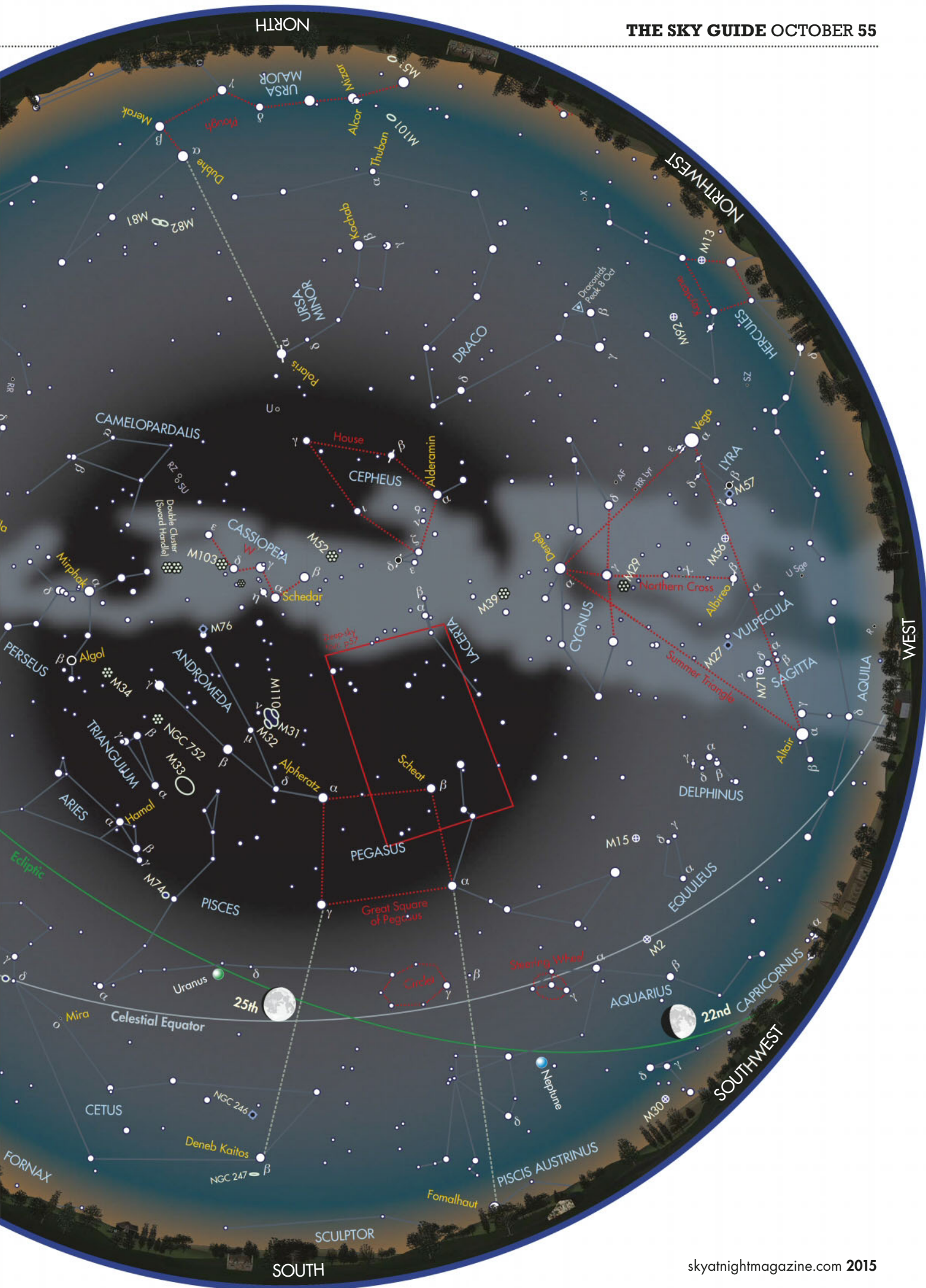


### MOONRISE TIMES

1 Oct 2015, 20:56 BST	17 Oct 2015, 11:58 BST
5 Oct 2015, —:—: BST	21 Oct 2015, 15:06 BST
9 Oct 2015, 03:35 BST	25 Oct 2015, 16:08 UT
13 Oct 2015, 07:49 BST	29 Oct 2015, 18:29 UT

\*Times correct for the centre of the UK

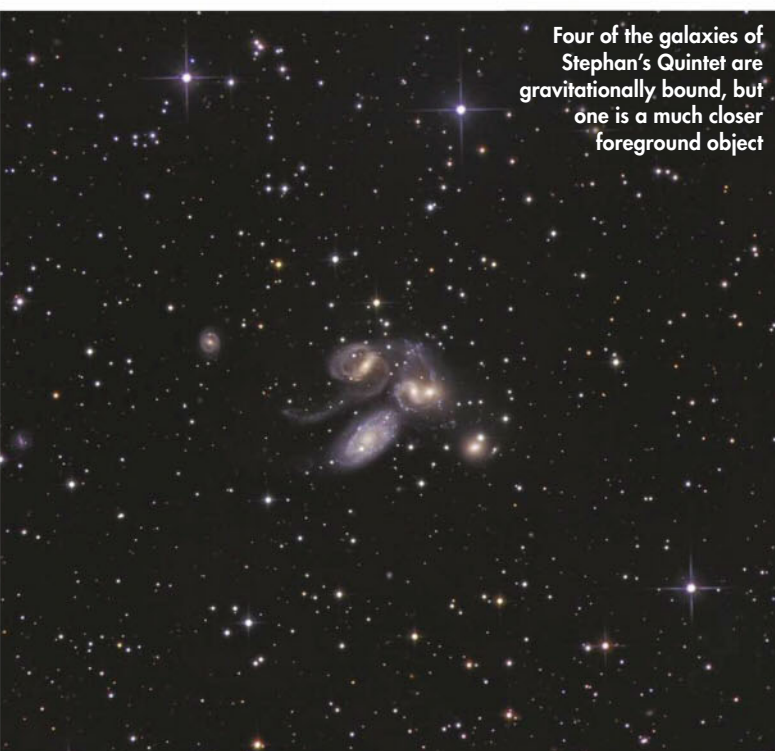




# Deep-sky tour

Train your telescope on some of the less famous objects near to the Great Square of Pegasus

☑ Tick the box when you've seen each one



Four of the galaxies of Stephan's Quintet are gravitationally bound, but one is a much closer foreground object

1

## THE BLUE SNOWBALL

☞ The Blue Snowball, NGC 7662, is a planetary nebula located in northern Andromeda. Through a small telescope, this relatively bright mag. +8.3 object is obviously not a star. Its 33x28-arcsecond disc also shows a weak bluish hue, hence its informal name. A 10-inch or larger scope shows a slightly darker inner region. The central blue-dwarf star is variable but hard to observe even with a large scope, the range of variability being mag. +12.0 to +16.0. To find NGC 7662, locate mag. +4.3 star Iota (i) Andromedae and extend a line towards mag. +6.0 Omicron (o) Andromedae. NGC 7662 lies a tiny bit south of the point roughly one-quarter of the way along this line. ☐ **SEEN IT**

2

## NGC 7640

☞ NGC 7640 is a barred spiral galaxy 1° and 50 arcminutes to the south-southwest of NGC 7662. The galaxy is almost edge on, resulting in it looking long and thin through the eyepiece. It is elongated north-south, with an apparent length of around 7 arcminutes, which is a respectable size. With an integrated magnitude of around +11.0, it's a decent challenge to see it with a small scope, but a 10-inch instrument shows the narrow ellipse to have a 3x1 arcminute core. A larger scope still refines this to around 1.5 arcminutes in length, although getting a decent view of it is tricky because there's a 'dazzling' mag. +13.1 foreground star virtually on top of it. ☐ **SEEN IT**

3

## UGC 12632

☞ The dwarf spiral galaxy UGC 12632 lies 1.5° to the east of NGC 7640. Though it is catalogued as being mag. +12.1, the fact that it covers an area 4.5x3.7 arcminutes across means that its surface brightness is low, making it harder to see than you might expect. You'll need a large telescope of 12 inches or greater aperture to see it convincingly, and a good dark, clear sky will help enormously too. At around 200x magnification it looks like a large but faint glow roughly 2 arcminutes in diameter. It's not easy to see any detail in UGC 12632 and the core isn't obvious at all. An isosceles triangle of 14th-magnitude stars frames the galaxy's glow. ☐ **SEEN IT**

4

## JONES 1

☞ We move south towards the Great Square of Pegasus asterism for our next object, the faint planetary nebula Jones 1. To find it, identify the two stars marking the northern edge of the square: mag. +2.1 Alpheratz (Alpha (α) Andromedae; not shown on chart) and mag. +2.4 Scheat (Beta (β) Pegasi). The area containing Jones 1 lies 1.5° north of the mid-point between them. The nebula can be seen with a 10-inch scope using an UHC or OIII filter, but larger apertures will make the task easier as the its surface brightness is very low. It's quite large at 5.5 arcminutes, and appears as an incomplete ring, a bit like a ghostly capital 'C'. ☐ **SEEN IT**

5

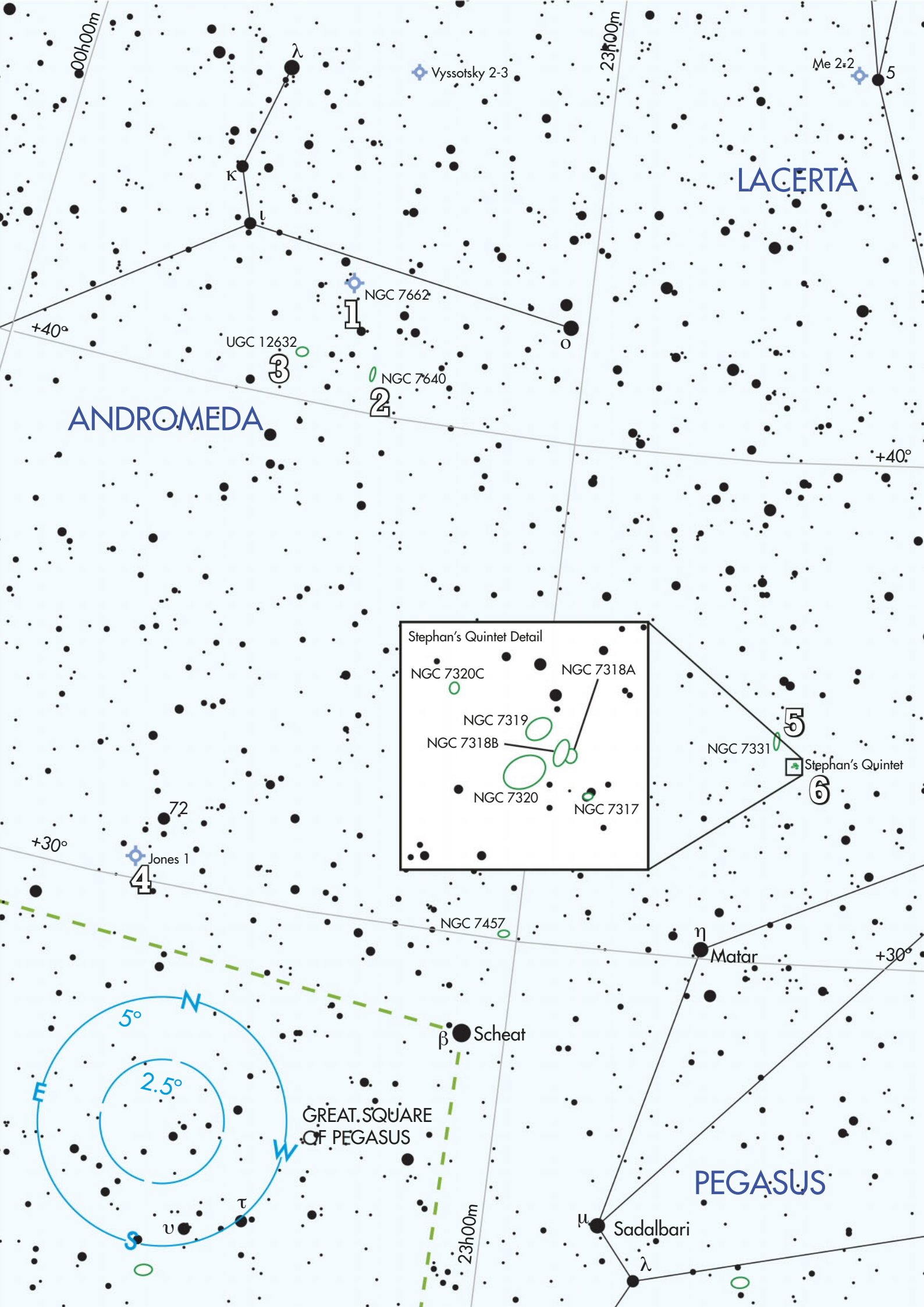
## NGC 7331

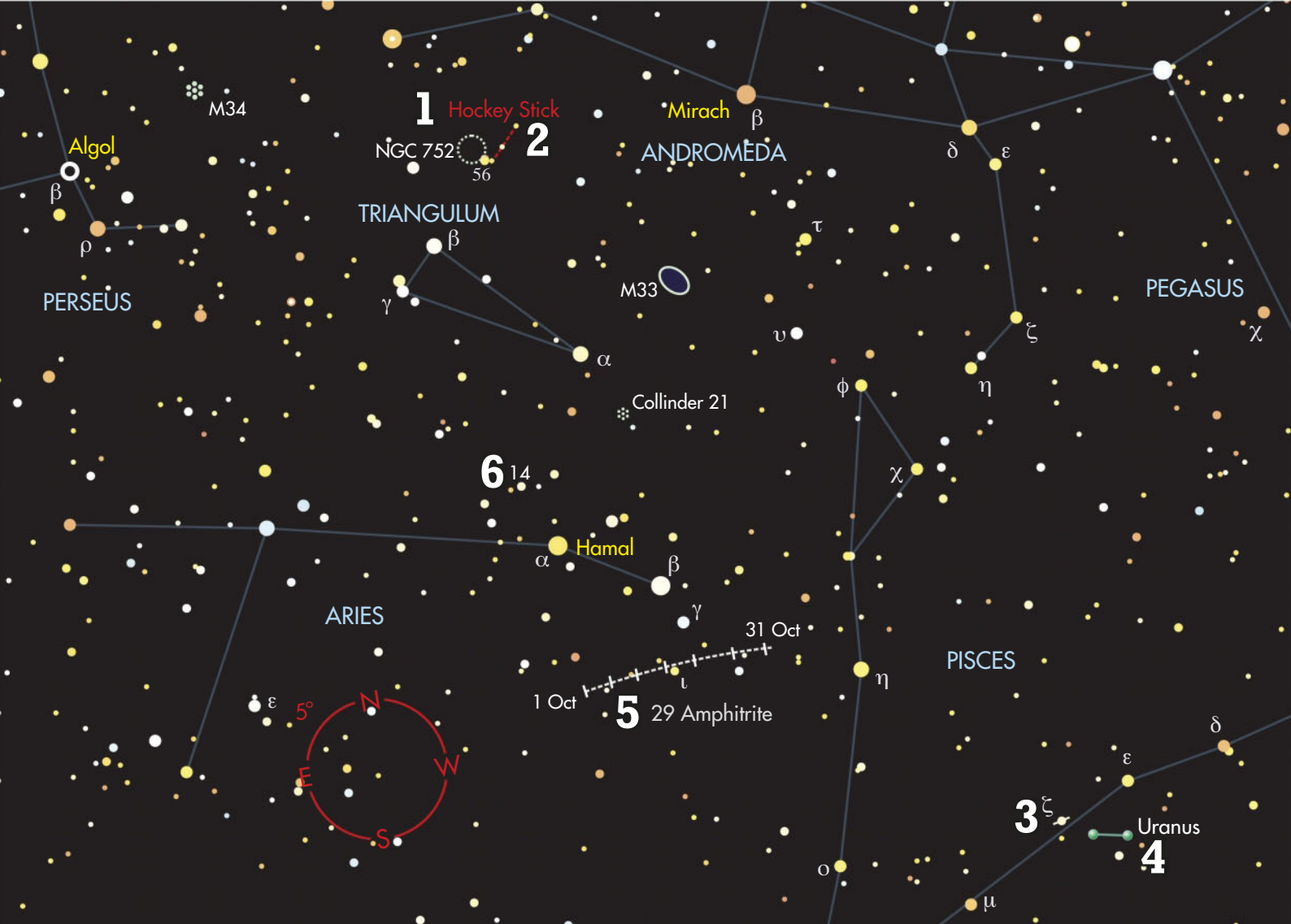
☞ Our next target, mag. +9.5, spiral galaxy NGC 7331, can be found by imagining a line from mag. +3.5 Sadalbari (Mu (μ) Pegasi) to mag. +2.9 Matar (Eta (η) Pegasi) and carrying on by three-quarters of the distance again. The galaxy appears as an elongated north-south glow in a small instrument, while a 10-inch scope will reveal the glow to be granular and 8x2 arcminutes in size, brightening to a star-like core. Even larger scopes show a dark dust lane across the western edge of the core. Unusually, the galaxy's core rotates in the opposite direction to its arms. ☐ **SEEN IT**

6

## STEPHAN'S QUINTET

☞ Our final target is Stephan's Quintet, a group of five faint galaxies in an area 3.5 arcminutes across. Located 0.5° southwest of our previous object, the brightest member is mag. +13.7 NGC 7320, a foreground galaxy 40 million lightyears away. The remaining four, all 290 million lightyears away, are NGC 7317, NGC 7318A, NGC 7318B and NGC 7319. A 10-inch scope will show four members of the Quintet, but you'll need a 12-inch instrument to reveal faint NGC 7319. Also note that the four galaxies 290 million lightyears distant also form Hickson Compact Group 92 with nearby galaxy NGC 7320C. These galaxies are gravitationally bound and undergoing violent tidal interactions with one another. ☐ **SEEN IT**





With  
**Stephen Tonkin**

## Binocular tour

The October skies glitter with sporting goods, a close asteroid and a trickily tight triple



☒ Tick the box when you've seen each one

### 1 NGC 752

**10x 50** We begin this month's tour with a very easy open cluster. Find mag. +3.0 Beta ( $\beta$ ) Trianguli (which is actually the brightest star in Triangulum) and place it at the bottom of the field of view; our target, mag. +5.7 open cluster NGC 752 should be near the top, just to the left of a close pair of 6th-magnitude deep-yellow stars. It may be visible to the naked eye. You should be able to resolve at least a dozen yellowish stars in an area of granular appearance that is nearly twice the apparent size of the Moon. ☐ **SEEN IT**

### 2 THE HOCKEY STICK

**10x 50** Look back to the pair of yellow stars near NGC 752. These stars, shining at mag. +5.6 and +5.9 respectively, are the components of the double star 56 Andromedae. They are separated by about 3 arcminutes, making them a very easy split, even to the naked eye. Rising to the right of them is a straight-ish chain of 6th- and 7th-magnitude stars, forming a 1.6° long asterism known as the Hockey Stick. The star

56 Andromedae is the business end, NGC 752 a large ball. This is a line-of sight association: at 1,300 lightyears, NGC 752 is four times more distant than 56 Andromedae. ☐ **SEEN IT**

### 3 ZETA PISCIIUM

**10x 50** Mag. +5.2 Zeta ( $\zeta$ ) Piscium lies in the southern chain of stars in Pisces. This is a challenging binocular double of two white stars (mag. +5.2 and +6.1) separated by only 23 arcseconds. It is a good test of your optics and the steadiness with which you hold your binoculars. If you find it difficult to split, mount the binoculars, make sure that your focus is perfect, and put the star exactly in the centre of the field of view. The brighter member is around 175 lightyears away, but this star is a not true binary, it's merely an alignment. ☐ **SEEN IT**

### 4 URANUS

**10x 50** Although Uranus is nominally of naked-eye visibility, in practice this is a feat that ranges from impossible to very difficult under

British skies. However, even small binoculars can transform this planet into an easy spot. At the beginning of October it is 1.25° south-southwest of Zeta Piscium and moves 1.25° further away during the month. It shines at mag. +5.7 and traverses the sky 1° north of a star of similar brightness. To be sure you've seen it, observe on several nights: Uranus is the one that moves in relation to the others! ☐ **SEEN IT**

### 5 29 AMPHITRITE

**15x 70** Asteroid 29 Amphitrite is usually right at the limit of binocular visibility, but this month it comes to opposition and brightens to mag. +8.7, bringing it comfortably into the range of medium-sized binoculars. As with Uranus, you will probably need to identify it as 'the one that moves', although you should be able to do this over a period of hours rather than days. It will be easiest to find around New Moon on the 13th, when it moves to within 2 arcminutes of mag. +5.1 Iota ( $\iota$ ) Arietis. Amphitrite is the third largest of the stony S-type (silicaceous) asteroids, after Eunomia and Juno. ☐ **SEEN IT**

### 6 14 ARIETIS

**15x 70** Our final object is challenging triple star 14 Arietis, which lies 2.5° north of mag. +2.0 Hamal (Alpha ( $\alpha$ ) Arietis). The brighter components (mag. +5.0 and +7.9) are separated by 105 arcseconds and easy to split. The third member is considerably fainter at mag. +11.3 and is 12 arcseconds closer to the primary. You will need averted vision and a dark, transparent sky if you are to glimpse it in 15x70s. ☐ **SEEN IT**

# Moonwatch

## Crater Prinz

THE 48KM CRATER Prinz is quite easy to locate thanks to its proximity to 40km Aristarchus, the brightest crater on the lunar near side. From Aristarchus, look northeast. Passing across the smooth lava surface where Oceanus Procellarum meets the Imbrium Basin, Prinz is the first feature you come to.

The crater itself has fallen foul of lava, appearing partially submerged beneath it. It's almost as if a pivot has been created along the southeast-northwest diameter of the crater, with Prinz tilted so that the northeast portion has raised itself above the

lava floor, while the southwest edge has disappeared below it. As a consequence, what's left looks a bit like a horseshoe with a flat internal lava floor.

Why one side of Prinz is lifted up relative to the other is a bit of a puzzle. One theory suggests that Prinz was formed on a slope and so only part of it became submerged when the lava of the Imbrium and Procellarum basins flowed. Another more likely idea is that the region to the north of Prinz may have bulged up from below due to volcanic forces. Certainly, nearby Aristarchus sits on a

plateau which is raised above its immediate surroundings and above the general level of the lava that frames it.

Although flat, Prinz's floor isn't without variation. There are ejecta markings crossing the floor. These show up best under high illumination, when the Moon's close to full, and

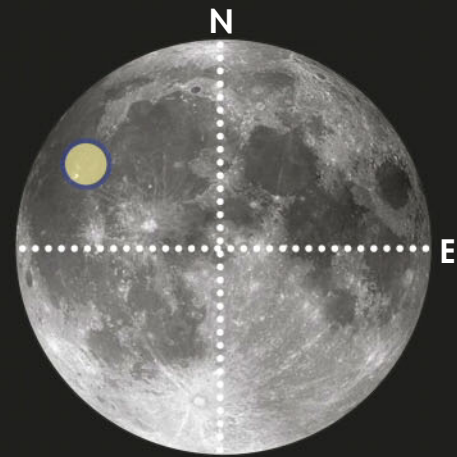
are most likely from the impact that created Aristarchus. We say most likely because there is a complex interchange of ejecta rays in this area of the Moon from Aristarchus, 31km Kepler and 93km Copernicus. Their rays criss-cross the region and there is some cross-contamination close to each of the impact zones.

The region to the immediate north of Prinz is complex and rugged. A set of rilles known as the Rimae Prinz exist here. Using a 8-inch or larger scope, look just outside of the rim of Prinz to the north and there you should be able to see a tiny 2km crater called Vera. A rille moves off from Vera, initially to the west before turning northward. Another rille can be seen north of Vera, this time starting close to the 4km crater Ivan. This too appears to head west before turning north. Together, both rilles are part of the Rimae Prinz complex. In total there are four main complex rilles and it's an interesting exercise to try and trace them as they meander around some mountain peaks found here.

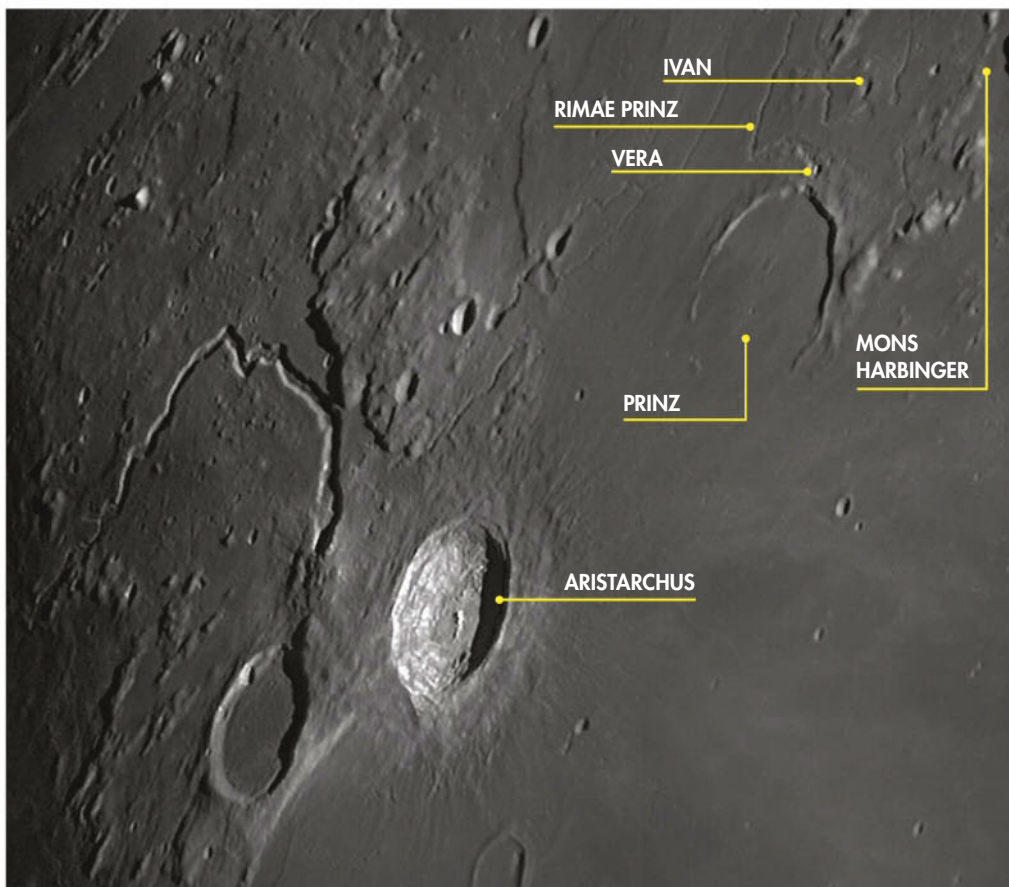
Mountainous peaks protrude to the northeast. These form the Montes Harbinger range and rise to a height of 2.5km above the lava floor below. Under oblique illumination, when the terminator's close, it's interesting to look over the Prinz region with the highest magnification the conditions will allow. There are a number of volcanic domes here, typically with dimensions less than 5km across.

### STATISTICS

**TYPE:** Crater  
**SIZE:** 48km  
**AGE:** 3.8-3.85 billion years  
**LOCATION:** Latitude 25.5°N, longitude 44.1°W  
**BEST TIME TO OBSERVE:** Three days after last quarter or four days after first quarter (8-9 October and 23-24 October)  
**MINIMUM EQUIPMENT:** 2-inch refractor



## “Why one side of Prinz is lifted up relative to the other is a bit of a puzzle”



Under high illumination you may be able to see ejecta markings – possibly from Aristarchus – on Prinz's floor

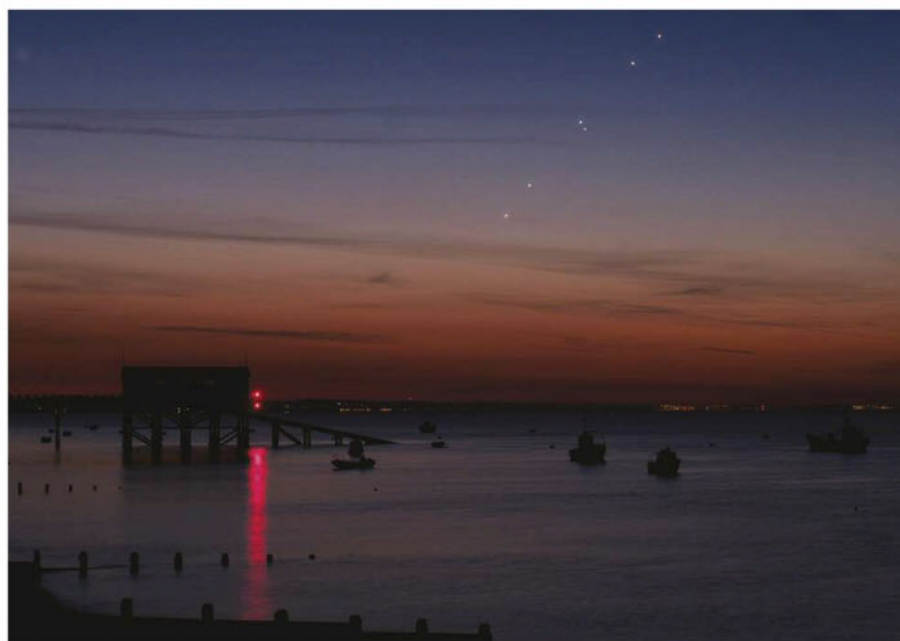
# Astrophotography

## A dynamic view of the Solar System



### RECOMMENDED EQUIPMENT

DSLR, tripod, remote shutter release



A composite shot – this one is of Venus and Jupiter – will reveal the planets' progression

CONJUNCTIONS BETWEEN PLANETS, or planets and the Moon, are reasonably common. There was a lovely example seen at the end of June this year, when Venus and Jupiter got very close in the evening twilight. Both planets are set to have another close encounter in this month's morning sky, but the event will be slightly different as they won't be alone!

The Venus-Jupiter conjunction at the end of June was particularly popular because it was visible in the evening sky. When they shift to the morning sky however, the attention drops because many will still be in bed. But if you make the effort this month you will be rewarded by the magnificent sight of Venus, Mars and Jupiter all appearing together close to the bright star Regulus in Leo. Mercury joins in too, although it'll be closer to the Sun. The Moon will be there as well during the second week of October. For details of times, see page 50.

As these planets are reasonably bright, they make great targets for a fairly simple camera setup. A DSLR with a 50mm

lens should be able to fit Venus, Mars and Jupiter in comfortably. A 28mm or shorter focal length lens will allow you to catch Mercury too.

This collection of bright dots really starts to come together if you photograph them over the course of several mornings. If you can catch them on every clear morning throughout October they can be made to show something really quite amazing; the relative motion of the planets in our Solar System. This helps to convey the three-dimensional aspect of the planets, something that doesn't come across at all in a single still frame.

The technique required is pretty straightforward. You'll need a location with a relatively flat east-southeast horizon. Set your tripod in a location to take your first photograph and mark the position of its legs so you can replicate this position on subsequent mornings.

The match doesn't need to be precise, but it helps to keep it fairly close.

It'll also be necessary to take your shots at the same time every morning. Accuracy here is more important. It's probably best to plan for two main shots. Take the first one early to catch Venus, Mars and Jupiter against a darker sky. The second can come later to include Mercury.

Aim to record at least three stars in the shot as well as the planets. These will act as reference markers, allowing you to create one animation of the planets relative to the background stars, as well as one relative to the horizon.

Opening camera lenses fully can lead to distortions at the edges of the frame. This isn't a requirement here as the scene will be relatively bright, so keep the aperture at around f/4-f/5.6 setting. An ISO setting of 400-1600 should also suffice. Aim to keep exposures to less than 10 seconds to avoid too much trailing, upping the ISO if necessary if you hit the 10-second limit.

As dawn approaches so the brightness of the background sky increases. This makes it impossible to suggest accurate, up to the minute settings. Consequently, it's really important to pay attention to the information your camera delivers about each shot. Don't assume that the settings you use for one morning will hold for other mornings too!

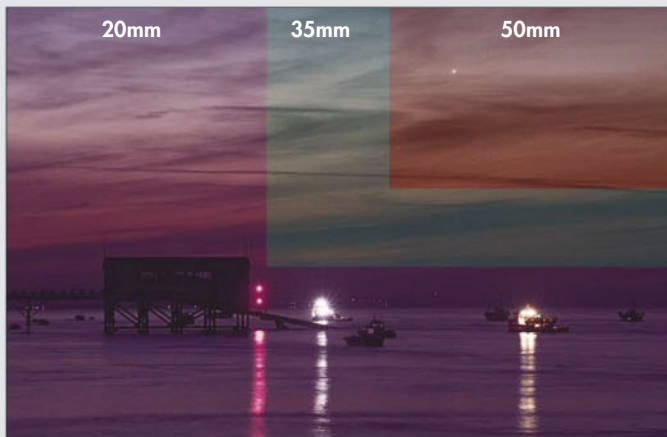
### KEY TECHNIQUE

#### TWILIGHT TRIFLES

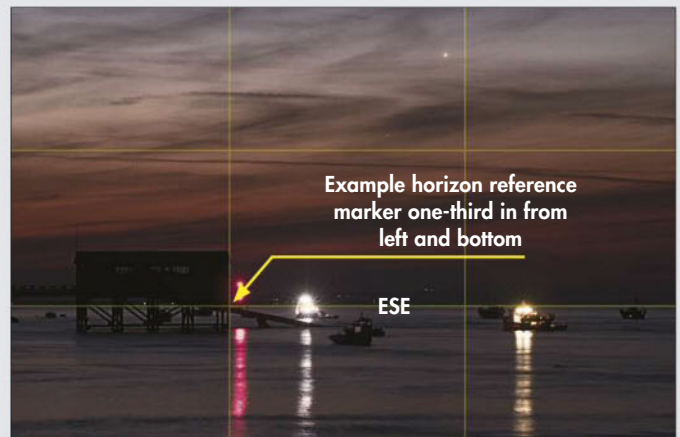
Twilight targets are tricky to get right because of the ever-changing light levels. This can be exacerbated by the weather, making it difficult to specify, or repeat, the right settings from one day to the next. But by reviewing the histogram of your shots on your DSLR, it's possible to adjust the camera settings to produce a similar result under different lighting conditions. This is done by adjusting the exposure so that the peaks of the histogram curve appear in the same relative horizontal position in the displayed graph.

✉ Send your image to: [hotshots@skyatnightmagazine.com](mailto:hotshots@skyatnightmagazine.com)

## STEP-BY-STEP GUIDE



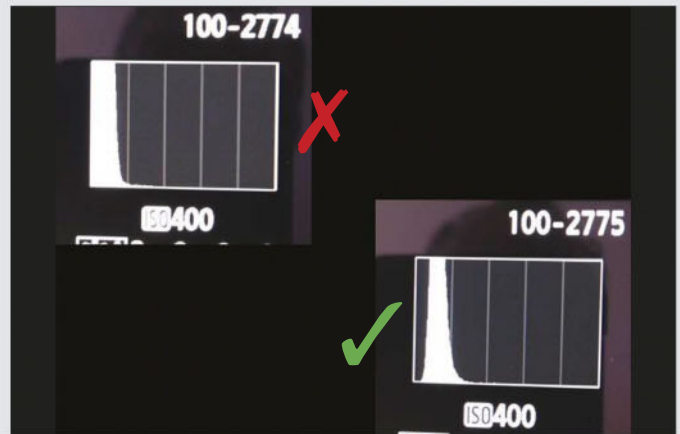
**STEP 1** Select a site with a reasonably flat eastern horizon. The maximum size of the Venus, Mars and Jupiter gathering is  $16^\circ$ , which will fit into a 50mm lens field of view. To include the horizon, closer to 35mm is required and for Mercury a 20mm or shorter lens is needed. Make a note of your tripod's location so it can be repeated.



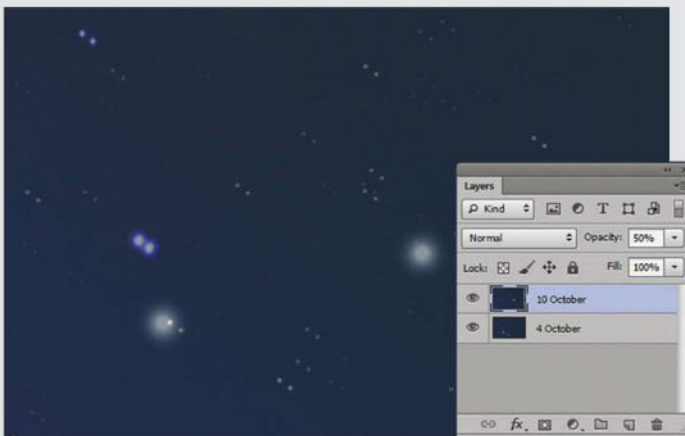
**STEP 2** Endeavour to keep the image frame's position relative to the horizon consistent between shots. Timing is important. For Venus, Mars and Jupiter, aim to take your photos at 05:15 BST (04:15 UT). For Mercury, 06:30 BST (05:30 UT) should give a decent level of darkness with all planets visible. Mercury only really joins the show from the 8th.



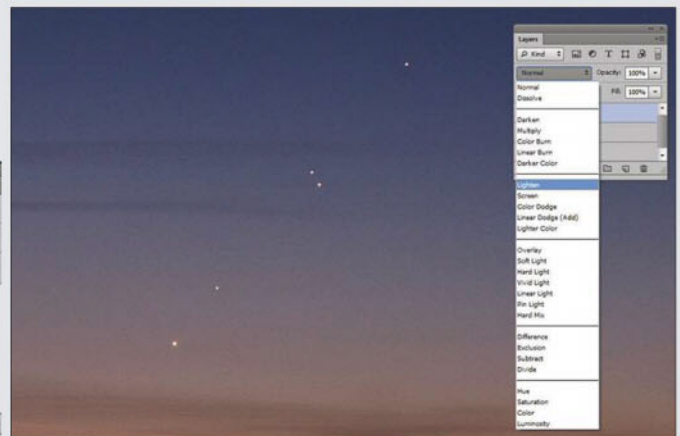
**STEP 3** Set the camera to manual, and the lens to manual focus. Pre-focus at infinity – the bright planets will be perfect for this using live view. Open the lens to around f/4-f/5.6 and set the ISO to a mid-level, say 400-1600. Use the lower value if your exposures work okay with it. Aim to take exposures lasting less than 10 seconds to avoid trailing.



**STEP 4** Take your shot and examine the histogram on the camera's review screen. The pixel data will probably be bunched towards the black point, but so long as it's not clipped – showing a sharp vertical edge against the graph's edge – then this will be fine. Make sure all planets record and at least three stars are visible in the image.



**STEP 5** Load each image into a layer-based editor in date order, oldest at the bottom. You have a couple of alignment options: working through the sequence, you can either align the horizon features to show the planets and stars moving together, or cut off the horizon and align the stars in the shot to show the movement of the planets relative to them.



**STEP 6** Set each upper layer's blend mode to Lighten. The brighter features from lower layers will show through to the final result. Depending on your Step 5 alignment choice, this will show the movement of the planets relative to the stars or both relative to the horizon. Save in the editor's native format, then flatten and save as a jpg or png.

# Dark Sky Telescope Hire



## Telescope Rentals

from £30/wk

delivery & collection  
service available

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UK-wide availability  
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amateur astronomers wanted!  
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[www.darkskytelescopehire.co.uk](http://www.darkskytelescopehire.co.uk)

E: [info@darkskytelescopehire.co.uk](mailto:info@darkskytelescopehire.co.uk) T: 07884 001815

# INSIGHT ASTRONOMY PHOTOGRAPHER OF THE YEAR

BBC Sky at Night Magazine reveals the winners of the world's biggest astro imaging competition

NATIONAL MARITIME MUSEUM LONDON X 9, BBC

**T**his year's newly expanded Insight Astronomy Photographer of the Year competition received more than 2,700 entries covering 60 countries, making the judges' work more difficult than ever. New categories were added to the competition for 2015, giving

entrants more opportunity to get creative behind the camera. This year there were eight: Aurorae; Skyscapes; Stars and Nebulae; Planets, Comets and Asteroids; Our Sun; Our Moon; Galaxies; and People and Space. Special categories Robotic Scope Image of the Year and the Sir Patrick Moore Prize for Best

Newcomer returned, giving remote efforts and new imagers the chance to have their astrophotos recognised.

Over the following pages, we present the winning images in all their glory, along with the verdicts revealing why they impressed this year's judges. These top entries will be on display in

**FREE**  
**2016 CALENDAR**



In the December issue of *BBC Sky at Night Magazine* we're giving away a free 2016 calendar featuring great imagery from the Astronomy Photographer of the Year 2015 competition. It's on sale from **20 November**.

a free exhibition at the Royal Observatory Greenwich that runs from 18 September until 26 June 2016, so be sure to visit and get inspired – remember, entries for next year's competition open in the new year!

[www.rmg.co.uk/astrophoto](http://www.rmg.co.uk/astrophoto)

## THE JUDGES



**Chris Lintott**  
Presenter, *The Sky at Night*



**Maggie Aderin-Pocock**  
Presenter, *The Sky at Night*



**Pete Lawrence**  
Presenter, *The Sky at Night*



**Marek Kukula**  
Public Astronomer, Royal Observatory Greenwich



**Melanie Vandenbrouck**  
Curator of Art, Royal Museums Greenwich



**Chris Bramley**  
Editor, *BBC Sky at Night Magazine*



**Jon Culshaw**  
Comedian and *BBC Sky at Night Magazine* contributor



**Will Gater**  
Astronomy journalist and author



**Ed Robinson**  
Photographer and director



Each year the winners and runners up are displayed at the Royal Observatory Greenwich



## ▲ AURORAE

### SILK SKIES

**Jamen Percy (Australia)**

**Photo location:** Abisko National Park, Sweden.

**Equipment:** Canon EOS 5D Mk III DSLR camera, 24mm lens.

**Judge's verdict:** "I love everything about this image – the cool colours and the contrasting textures of the snow and sky." – Marek Kukula.

## OUR SUN ►

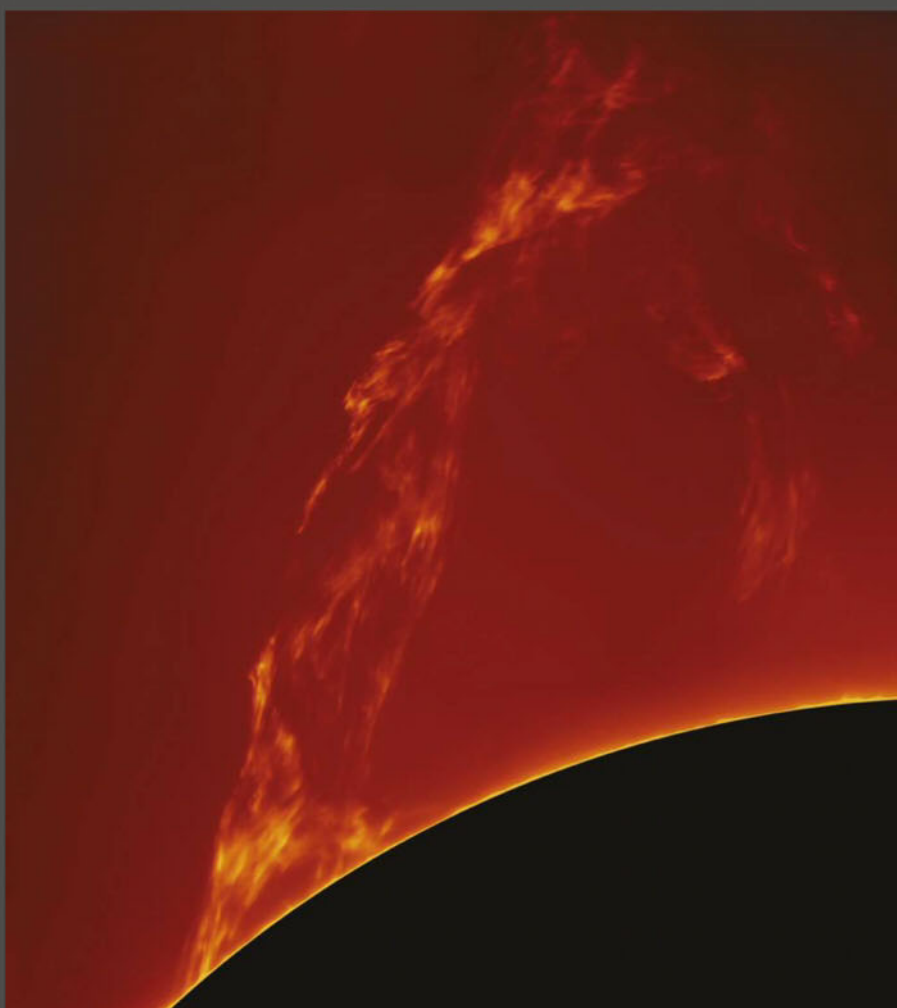
### HUGE PROMINENCE LIFT-OFF

**Paolo Porcellana (Italy)**

**Photo location:** Asti, Italy.

**Equipment:** Point-Grey Chameleon mono CCD camera, home-made 6-inch truss refractor, Sky-Watcher AZ-EQ6 mount.

**Judge's verdict:** "I absolutely love this picture, showing the blistering kiss of the Sun on the photographic lens. It conveys how fiery, destructive, but also alluring our very own star can be." – Melanie Vandenbrouck





## ◀ YOUNG ASTRONOMY PHOTOGRAPHER OF THE YEAR

### A CELESTIAL VISITOR

**George Martin (UK, aged 15)**

**Photo Location:** Market Harborough, Leicestershire, UK.

**Equipment:** Nikon D3200 DSLR camera, Sky-Watcher 200P Newtonian reflector, Sky-Watcher EQ5 motorised equatorial mount.

**Judge's verdict:** "Great capture of the colour of Comet Lovejoy, wonderful detail in the tail filaments. The star trails give great energy and a sense of movement to the shot." – Jon Culshaw

## GALAXIES ▶

### M33 CORE

**Michael van Doorn (Netherlands)**

**Photo location:** Almere, Netherlands.

**Equipment:** Starlight Xpress SXVR-H18 CCD camera, Celestron C11 Hyperstar Schmidt-Cassegrain, ASA 2-inch reducer-corrector.

**Judge's verdict:** "This is one of the best images – amateur or professional – of M33 I've ever seen. The mass of sparkling blue stars and ruby-red nebulae really draw your eye deep into the picture." – Will Gater



## ◀ STARS & NEBULAE

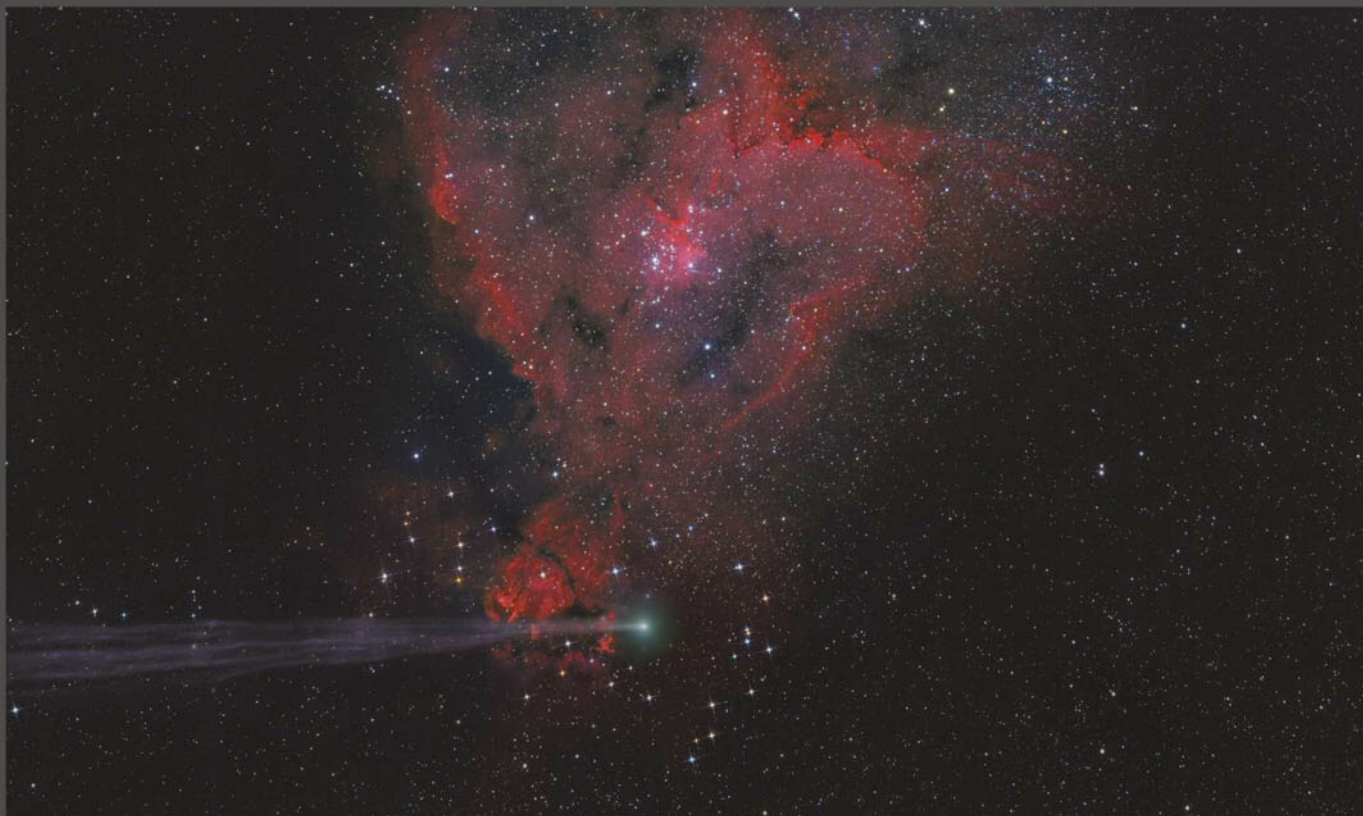
### THE MAGNIFICENT OMEGA CENTAURI

**Ignacio Diaz Bobillo (Argentina)**

**Photo Location:** San Antonio de Areco, Buenos Aires, Argentina.

**Equipment:** Canon EOS 6D Baader-modified and Peltier-cooled DSLR camera, Astro-Physics 130mm Starfire EDF Gran Turismo apo refractor.

**Judge's verdict:** "I love the depth, texture, and tonal range of this picture, its rich surface quality and the astonishing density of the stellar swarm. It reminds me of the 19th-Century's Pointillist painters, and their work on the theory of perception." – Melanie Vandenbrouck



## ▲ PLANETS, COMETS & ASTEROIDS

### THE ARROW MISSED THE HEART

**Lefferis Velissaratos (Greece)**

**Photo location:** Strethi mountain, Corinthia, Greece.

**Equipment:** SBIG STL-11000M CCD camera, Takahashi FSQ-106 ED quadruplet refractor, EQ8 mount.

**Judge's verdict:** "A tough picture to do well because the comet moves relative to the background nebula. Some great structure is visible in the comet's tail and a lovely contrast between the red nebula and the comet's head." – Pete Lawrence

## ▼ PEOPLE & SPACE

### SUNSET PEAK STAR TRAIL

**Chap Him Wong (Hong Kong)**

**Photo location:** Sunset Peak, Lantau Island, Hong Kong.

**Equipment:** Canon EOS 6D DSLR camera, 14mm lens.

**Judge's verdict:** "A very moving and imaginative interpretation of the category theme. I love the way the human presence is revealed by light, and there's a great sense of connection between Earth and the wider Universe." – Marek Kukula





## ◀ OUR MOON

### FULL FACE OF OUR MOON

**András Papp (Hungary)**

**Photo location:**

Veszprémvarsány, Hungary.

**Equipment:** Imaging Source DMK41AF04 camera, GPU Optical 5-inch telescope, Sky-Watcher HEQ5 mount.

**Judge's verdict:** "The perfect symmetry of this half-Moon shot gives it a very striking appearance. The combination of crisp detail on the sunlit side and the faint glow of reflected earthlight on the dark side is very impressive." – Marek Kukula

## ▼ ROBOTIC SCOPE

### COMET C/2013 A1 ALONGSIDE MARS

**Sebastian Voltmer (Germany)**

**Photo location:** Siding Spring Observatory, New South Wales, Australia.

**Equipment:** SBIG STL-11000M CCD camera, Takahashi FSQ ED astrograph, Paramount ME mount.

**Judge's verdict:** "A tricky subject as the comet will have been moving relative to Mars and the stars. Also hard to get right because of the brightness of Mars. A really lovely result, which shows off the delicate cosmic dance of comet and planet. A clever use of shared observations to record a sharp luminance as well as the all-important colour information to bring the scene to life." – Pete Lawrence



## ▲ SIR PATRICK MOORE PRIZE FOR BEST NEWCOMER

### ORION DT

**David Tolliday (UK)**

**Photo location:** Elan Valley, Powys, UK.

**Equipment:** Canon EOS 5D Mk III DSLR camera, Astrotrac mount, 500mm lens.

**Judge's verdict:** "To capture such a delicate image of this region in Orion is impressive, but to do it on a first night imaging under the stars is remarkable. A worthy winner." – Chris Bramley



INSIGHT  
ASTRONOMY ✨  
PHOTOGRAPHER  
OF THE YEAR

# OVERALL WINNER

## SKYSCAPES

**SPONSORED BY INSIGHT INVESTMENT**

ECLIPSE TOTALITY OVER SASSENDALEN

**Luc Jamet (France)**

**Photo location:** Spitsbergen, Svalbard, Norway.

**Equipment:** Canon EOS 7D DSLR camera, 16mm lens.

**Judge's verdicts:** "It is one of these heart-stoppingly beautiful shots for which you feel grateful to the photographer for sharing such an exceptional moment. The delicate disc of the occulted Sun is perfectly silhouetted in the sky, and you can almost feel the below-zero temperature, the cool breeze of the Arctic. The snow is pristine, as if no one had ever stepped on it. This is an otherworldly landscape, which could be on an as yet unexplored planet." – Melanie Vandenbrouck

"This is just a supremely beautiful image, which got joint admiration from all of the judges. The colours are perfect and the blend of the isolated snowy landscape frames the surreal majesty of the totally eclipsed Sun perfectly. It's an incredibly peaceful image." – Pete Lawrence



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# THE SCIENCE OF FICTION

John Gilbey joins a group of fellow sci-fi writers keen to learn more about the science behind their stories



**I**t was like the opening sequence of a big-budget science-fiction movie. Three SUVs driving in convoy on an arrow-straight road across the plains of Wyoming, the setting Sun giving a warm glow to the fringes of the Rocky Mountains as we headed west into the foothills.

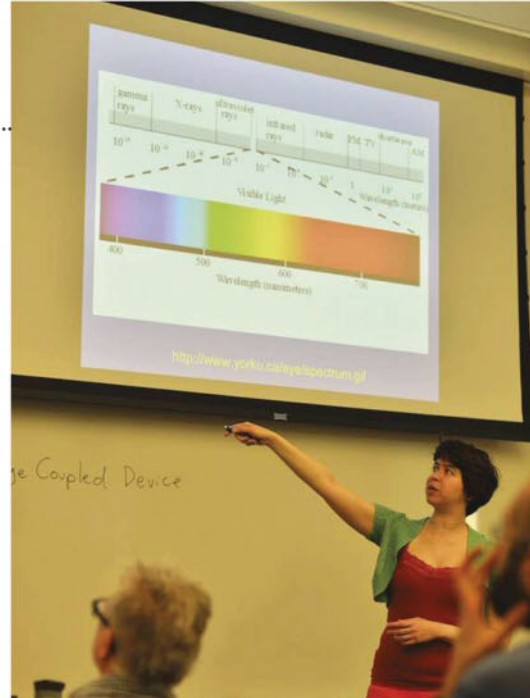
The track edged upwards until it hit the top of the ridge. Ahead of us, at the summit of Jelm Mountain, around 3,000m above sea level, stood the metal dome of the Wyoming Infrared Observatory (WIRO) with its 2.3m

▲ Launchpad 2015 members at WIRO's 2.3m telescope

telescope and spectacular views of both the night sky and the surrounding country.

I was at the Launch Pad Astronomy Workshop at the University of Wyoming – a week of astronomy tuition for writers who want to get the science right in their stories. To prove how serious the intent is, the week is funded by sponsors such as the Space Telescope Science Institute – well known purveyors of Hubble imagery and other insights.

Launch Pad was founded and is run by Mike Brotherton, a professor in the Department of ▶



► Physics and Astronomy at Wyoming and himself a published science-fiction author. His aim is simple: to improve the quality of the science in sci-fi, even among authors who already have a science background.

As Mike puts it, you need to “prioritise wanting to get it right over knowing you are right”, an ambition that is especially important in an area such as cosmology, where fundamental discoveries are rumbling over the horizon at what writers like myself view as an alarming rate. I asked Mike what led him to set up Launch Pad. “When I became a professor I used science-fiction in my astronomy courses, with both good and bad science, in order to reach students and liven up a lecture,” he explains. “It occurred to me that writers usually didn’t set out to put bad science in their stories. They wanted to get it right. I thought there

▲ Above left: the telescope dome at WIRO; Above right: astrophysics grad student Andria Schwartz teaching at Launch Pad 2015

might be interest in a crash course in astronomy designed to help writers get up to speed on modern astronomy and give them resources and confidence to tackle more science-heavy subjects.”

## Mind over dark matter

“If you need get out a calculator or do a calculation while writing the story, it is hard-science fiction,” says Mike. But the need for accuracy in the science of sci-fi isn’t restricted to hard science topics, and the range of authors at Launch Pad reflected that, with a number of fantasy writers also being present. Even a vampire or werewolf story has a need to get the portrayal of lunar phases right, and in the correct order.

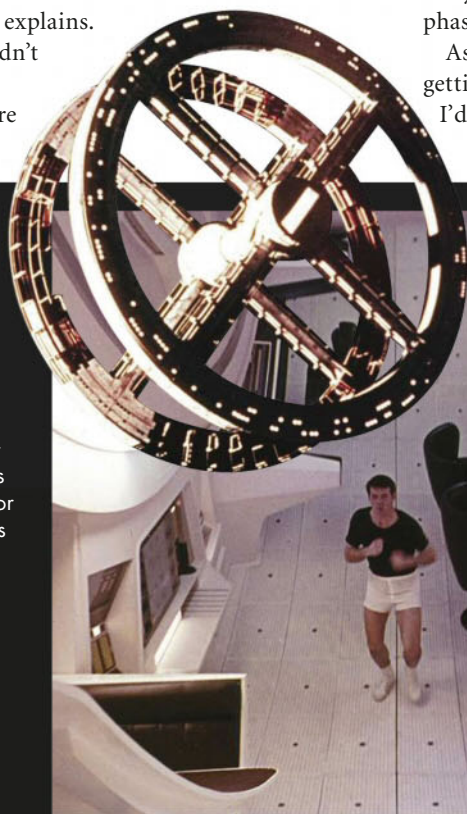
As someone who once narrowly avoided getting a science-fiction story published in which I’d referred to the Moon as a planet – I was

## THE GRAIL OF REALISM

As far as sci-fi films go, there is one that stands out

Almost every astronomer and science-fiction writer I’ve talked to has their favourite ‘shout at the screen’ moment – where physical laws are displaced by film-makers in the search for cinematic impact. Top billing frequently goes to explosions apparently clearly audible in space or the convenient existence of an Earth-like gravity effect on a tiny spaceship without an obvious mechanism – such as rotation – being displayed.

It doesn’t have to be that way. More than 40 years after its release, *2001: A Space Odyssey* is still remarkable for the close attention to detail in presenting accurate science. The rotation of the space station in Earth orbit, and of the crew deck in the *Discovery One* spacecraft, provide a visually engaging backdrop to the story – especially when the circular control room is used as a running track. The depiction



2001's *Discovery One* spaceship span to create its apparent gravity

of the silence of space, reflected by mechanical noises and stressed breathing-sounds in both pod and spacesuit, still has the power to shock. The challenge for

writers and film-makers today is to produce similarly effective, scientifically convincing material – an aim this workshop helps to achieve.

saved from ignominy by an alert copy-editor – I felt I was an obvious candidate for the course. I was very pleased to get a place at Launch Pad, albeit on my second attempt, and the reality of the event more than met my expectations.

What makes Launch Pad so special? Well, for a start it is a total immersion experience, a boot camp in which a dozen or so writers are housed together in a self-catering student house on campus. Around six hours a day are devoted to lectures and practical lab sessions – such as spectroscopy and working with Hubble images – and then, after a quick break off-campus for a beer and a burger, the evening session drifts into the really fun stuff: planetarium shows, telescope time in the rooftop dome, observation of the Jovian moons from the terrace outside and visits to the University of Wyoming's observatories.

After a day of constant activity, it was great to be able to sit and exchange views with people who you were slowly getting to know. These were people with the strong bond of a delight in both astronomy and science fiction – and as the week wore on we discovered we had both friends and favourite stories in common. Each tale recounted by a member of the group brought a "That reminds me of the time..."

## BAD SCIENCE, BAD FICTION

Though writers are often the cause of factually flimsy fiction, sometimes the science is to blame

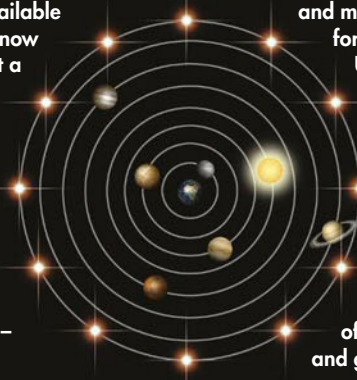
It is easy to be smug about what we know about astronomy and cosmology today and what people misunderstood in the past. 'Correct' science is, after all, only the currently accepted theory that can be supported by the available evidence. We know now that we don't inhabit a geocentric universe, or indeed a heliocentric one.

Early estimates of the structure and environment of our neighbouring planets have repeatedly been shown to be flawed – but this is not only a historical trait. Even a year ago, how many planetary scientists would

have put up their hands and suggested that Pluto would turn out to be such a varied, interesting and apparently active world?

Science is about suspecting, testing, accepting or rejecting, correcting and moving on. As our tools

for investigating the Universe become more sophisticated, gather more data and gain additional resolution, whole areas of work are moving from science-fiction to science reality. The rapidly growing list of potential exoplanets and growing research into multiverse theory, both long-time staples of science fiction, are just two examples.



▲ We once thought Earth was at the centre of a geocentric Universe



▲ Launch Pad delegates learn hard science in the WIRO control room

◀ Observing the night sky with a Meade LX200 at Launch Pad

▼ WIRO's 2.3m Cassegrain telescope is optimised for infrared observing



from someone else, leading to fantastical and irreverent discussions – that encompassed cultures both human and alien, sciences real and imagined – that extended late into the night.

Seeing big telescopes up close is always a rush for a science geek, and a 2.3m mirror looks a lot bigger than that when you're in the same room as it. As we were shown around the facility I began to fantasise about living in this mountain-top retreat, observing and writing while surrounded by the wilderness – especially when I learned that in winter the site is only accessible by snowcat.

Launch Pad brought home to me just how much has changed since I last looked seriously at the science – and there remains a feeling of regret that folk just don't look through telescopes to do science the way they once did. The whole field of dark matter and dark energy is both a shock and delight to a science-fiction writer, opening up both new areas of study and opportunities for story telling – with a massively bigger canvas. For me, one image summed up the week: the classic 'smoking gun' photo of the Bullet Cluster, said to be our best evidence to date for the existence of dark matter. As I look forward to my next project, I'm sure that my experience at the Launchpad will improve my writing. **S**



### ABOUT THE WRITER

John Gilbey is a science and science-fiction writer based in west Wales. He also teaches computer science at Aberystwyth University. Find him on Twitter @John\_Gilbey

# AN END TO EXPENDABILITY?

## REUSABLE ACCESS TO SPACE

With the UK and US both proposing solutions to the expendable rocket problem, **Ashley Dove-Jay** asks: do the numbers stack up?

**L**aunching satellites, space probes and people into orbit is expensive because of one major hurdle: we only use our launch vehicles once. Having delivered their payloads to space, our rockets either burn up in the atmosphere or crash into the ocean. The fuel in a rocket only accounts for about one-thousandth of the total cost of a launch. How expensive would a flight between London and LA be if the Boeing 747 you sat in had to be thrown away after one flight? Not many people could or would be willing to pay that – the commercial airline industry would be near non-existent. Such is the situation with the commercial space industry.

For decades we have battled to find our way around this problem, but two solutions are beginning to emerge: spaceplanes

and reusable rockets. Spaceplanes are vehicles with wings and rocket engines. They take off and land like an aircraft, but get an extra boost in altitude to suborbital heights with rockets, where aerodynamics are near negligible. Reusable rockets, on the other hand, take off like a conventional rocket and land vertically using retro-boosting techniques and relatively minimal aerodynamics.

We are familiar with aircraft and perceive them to be safe enough for more than 100,000 flights to be made a day. So, you might

imagine that spaceplanes would be more desirable for space tourism than a rocket with a crew capsule. But spaceplanes are yet to deliver a compelling safety record. Of the 135 manned Space Shuttle missions, two ended in tragedy, one through an issue with the rocket launching it and one through a heat shield failure.



The two most advanced rocket replacements are the Skylon spaceplane and Falcon reusable launch system; one day, there might be room for both



### ABOUT THE WRITER

Ashley Dove-Jay is a PhD student in Aerospace Engineering, a graduate of the International Space University and an engineer at Oxford Space Systems.

Virgin Galactic is also pursuing the development of spaceplanes. Its air-launched SpaceShipOne became the first private manned spaceflight in 2004, but its successor – SpaceShipTwo – broke up mid-flight in October 2014.

## Transport of tomorrow

Nevertheless the spaceplane concept is still being developed. It is a more popular choice for hypersonic transportation around Earth than rocket flights, but the question remains whether they will reach higher than low-Earth orbit. The only destinations in our Solar System where a spaceplane could fly would be Venus and Titan. Mars, the major destination for current space agencies, has an atmosphere so tenuous it renders spaceplanes impractical.

But what about getting cargo into orbit? There are numerous groups tackling this problem. The Indian Space Agency is already demonstrating an advanced

reusable spaceplane prototype, the Avatar. It is currently being launched by an expendable rocket for development trials, but is planned to take off and land like an aircraft when in full operations.

Airbus has recently revealed Adeline, a concept for a first-stage rocket engine for the Ariane 6 that glides back to Earth and lands on a runway like an aircraft. Virgin Galactic is looking to reduce the size of the expendable rocket wasted in getting payloads to orbit by launching them from a specialised carrier aircraft. Bristol Spaceplanes has proposed a two-stage concept: a hypersonic carrier aircraft (think of a larger and faster version of the Concorde) that a small spaceplane launches from.

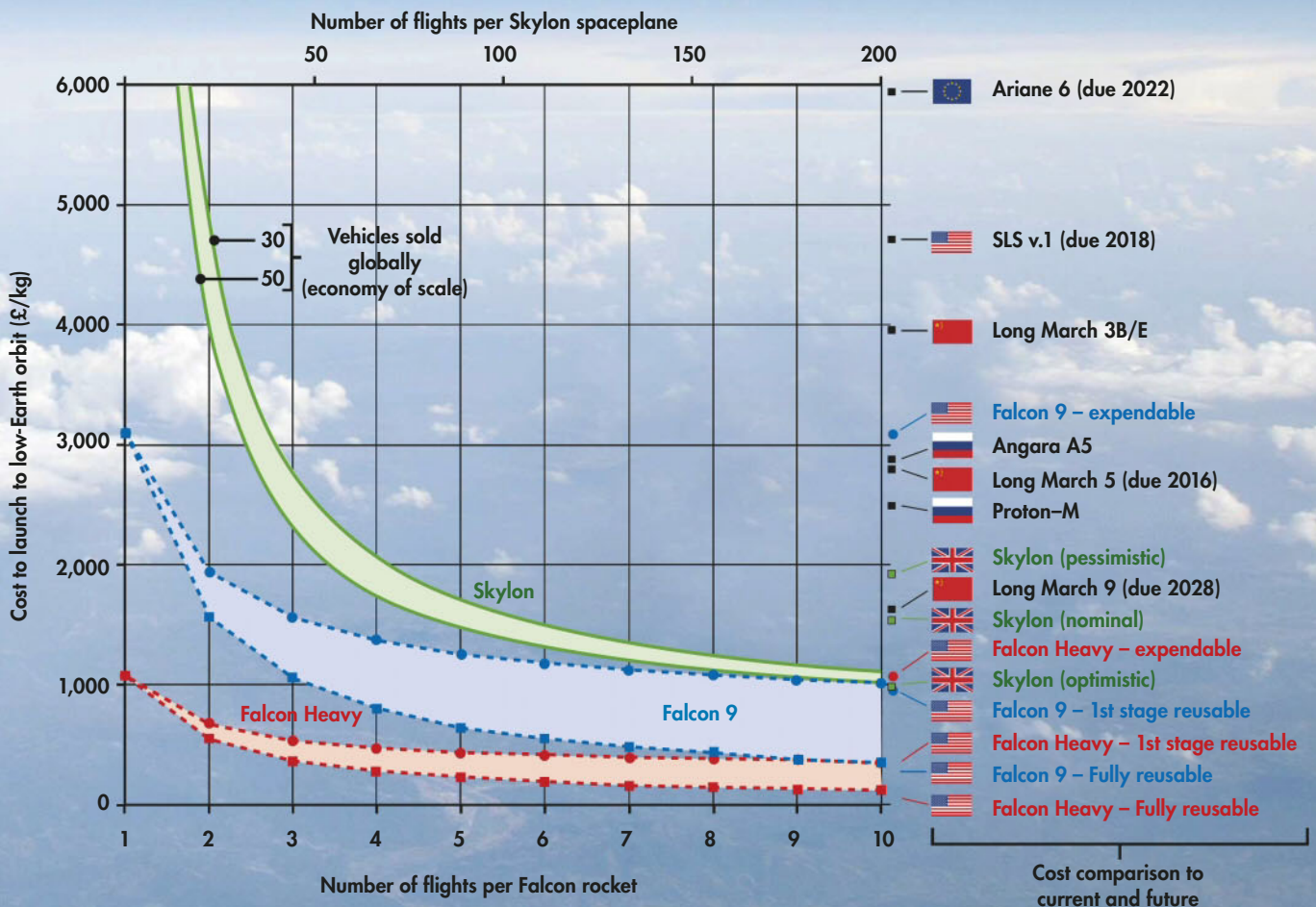
Then there are the designs that are perhaps most matured, Reaction Engines' Skylon spaceplane and SpaceX's Reusable Launch System, an add on to its Falcon rockets. The approaches these last two companies are developing serve as useful

examples of the two solutions to the expendable rocket problem: reusable rockets and reusable spaceplanes. Both of their ideas are compelling. But if both take flight, which will be the more cost effective? And if there are significant differences in cost, will that make one of these technologies the outright preferred choice? Think of aeroplanes and helicopters: though it is an option, people very rarely use helicopters for intercontinental transportation; each craft is suited to a different purpose.

To look at the economics of these two alternatives, it's useful to have a graph showing the cost to launch for low-Earth orbit (below). Running along the top of this is the number of launches per Skylon spaceplane, from one to 200, and along the bottom are the number of launches per Falcon rocket from one to 10. Both of these relate to the number of flights we can expect from each vehicle within their operational lifetimes. The vertical axis ▶

## LAUNCH TO LOW-EARTH ORBIT

The graph compares the projected costs of spaceplane and reusable rocket flights to low-Earth orbit. Even with pessimistic projections for an operational Skylon programme, it beats all equivalent conventional rockets hands down. On the other hand, the inherently higher operational and insurance costs of Skylon means it would struggle to economically compete with even partially reusable rockets.





▲ Skylon isn't the only spaceplane in development – from left: the Indian Space Agency's Avatar; Airbus's conceptual vehicle Adeline; and Bristol Spaceplanes hypersonic carrier aircraft 'Ascender'. All three have wings for providing atmospheric lift at take-off and landing

► shows the cost to launch 1kg of payload to low-Earth orbit, which is where the International Space Station is.

It's on cost that one of the major differences between spaceplane and rockets becomes apparent. With the single-use configuration in which they are currently flown, the Falcon 9 and Falcon Heavy respectively cost about £40m and £56m per launch. Once first-stage reusability is established, launch prices should drop to £13.5m and £19m respectively, and if the whole rocket is reusable these costs could drop further to about £4.6m and £6.5m per launch.

With economies of scale taken into account, the cost of the Skylon spaceplane is in the region of £1.1-£1.4bn. And with

the best-case scenario plotted on the graph, the cost per flight of the spaceplane is in the region of £22m; £39m is probably closer to reality. However, a spaceplane is likely to be used a lot more than a rocket.

### Returns on investment

The Skylon would see a slower return on investment. Each spaceplane would need to fly about 200 times before it starts to match the cost of a first-stage reusable rocket that flies 10 times. With an average of 80 launches per year over the past five years, the market is currently not large enough to support such numbers. The 'best-case', 'nominal' and 'worst-case' points on the chart relate to these market projections, and point to the fact that this

is a market in its infancy: who is to say what new market demands will emerge with launch prices dropping so radically over the coming decades.

As both spaceplane and rockets are used more frequently, the less the initial costs contribute to launch costs. Taking into account the life-expectancy of each vehicle, we arrive at the situation to the right of the graph. Now operational costs that are initially noise in the background become the dominating factor, and so launch costs no longer continue to fall. These operational costs are associated with launch facilities, fuel and insurance.

To launch, a Skylon spaceplane would use a 5km long runway (Heathrow's longest runway is 3.9km); a Falcon Heavy

## THE REUSABLE SPACEPLANE SKYLON

**Length** 85m • **Dry mass** 52 tonnes • **Take-off mass** 325 tonnes  
• **Payload to LEO** 15 tonnes • **Vehicle cost** £1.1-£1.4bn •  
**Fuel cost** £820k • **Reusability** Approx 200 flights

Skylon is being developed by Reaction Engines, which is working on producing the engine for an all-encompassing launch vehicle that takes off and lands like a normal aircraft, yet flies into orbit. The company is looking to achieve this with a jet-rocket hybrid engine called SABRE. ESA has confirmed all aspects of the engine are valid and, along with the UK Government, is funding the development of a full demonstrator. Reaction Engines has also developed a vehicle to use this engine, the Skylon spaceplane. ESA is exploring the potential for establishing Skylon as one of its launch vehicles by 2027.

## THE ROCKET WITH A REUSABLE FIRST STAGE FALCON 9

**Length** 83m • **Dry mass** 25 tonnes • **Take-off mass** 506 tonnes • **Payload to LEO** 13.2 tonnes • **Vehicle cost** • £40m  
**Cost £/kg to low-Earth orbit** • £1,100 (best case), £1,500 (nominal) • **Fuel cost** £131k • **Reusability** Approx 10 flights



SpaceX is working to create a two-stage rocket system, the Falcon, that takes off from a launch-pad like a normal rocket and then lands back at the launch-pad vertically, using its rocket engines. Two Falcon 9 re-entries landed successfully in water in 2014, followed by two failed re-entry landings on barges in January and April this year. If the technique is mastered the company wants it to become the norm for its launches in the coming years. Though a reusable second stage is still an open question, SpaceX is also refining its Dragon capsule, currently used to take cargo to the ISS, for use as a human transport.



launches from the equivalent of a large helipad. It is reasonable to assume that, one day, spaceplanes would launch from established major airports, reducing the launch facility costs greatly, which is an option not open to rockets. However, for now, the UK's first spaceplane spaceport will likely be located in a relatively remote coastal location.

Because of the different fuel used in each, Skylon costs about six times as much to refuel as a Falcon 9 and about two times as much as a Falcon Heavy. And since there's a difference in vehicle value, insurance costs play a role: the Skylon needs to fly about 200 times without incident; Falcon rockets need to fly about 10 times. Regardless of how high market demand soars in the future, it is these operating costs that mark the key economic difference not only between the Skylon and Falcon launch programmes, but between reusable spaceplanes and rockets in general.

There is also another factor that feeds into the economics of this area, and that is legislation. The US government's

International Traffic in Arms Regulations (ITAR) limit the trade in defence-related goods and services, and was greatly expanded after an incident with China in 1996. It was suspected that the Chinese stole American encryption devices attached to an Intelsat satellite after a failed launch with a Long March 3B rocket. Commercial satellites and other space-related equipment now come under the regulations.

## Americans only

A consequence of this is that SpaceX has a challenge getting non-US customers, and has little chance of working with other governments. Globally, government customers currently consist of two-thirds of the launch market. If nothing changes on this front, SpaceX will remain restricted from a market Skylon has access to. Within that market, as far as can be seen, Skylon would have no real competition. However, over the past year, small steps have been made in relaxing regulations on satellites. Only time will tell if these changes will

extend to commercial launch operators such as SpaceX.

There are operational differences too. There is about a decade of development and testing ahead for Skylon, along with about £14 billion of investment. SpaceX, valued at £8 billion, is a few years away from an operational reusable first stage for Falcon 9. Compared to expendable rockets, current and future, Skylon is an excellent answer, but once partially reusable rockets become the norm the game changes. From a financial perspective, it seems to make more sense to use a first-stage reusable rocket. The question of risk remains open, however.

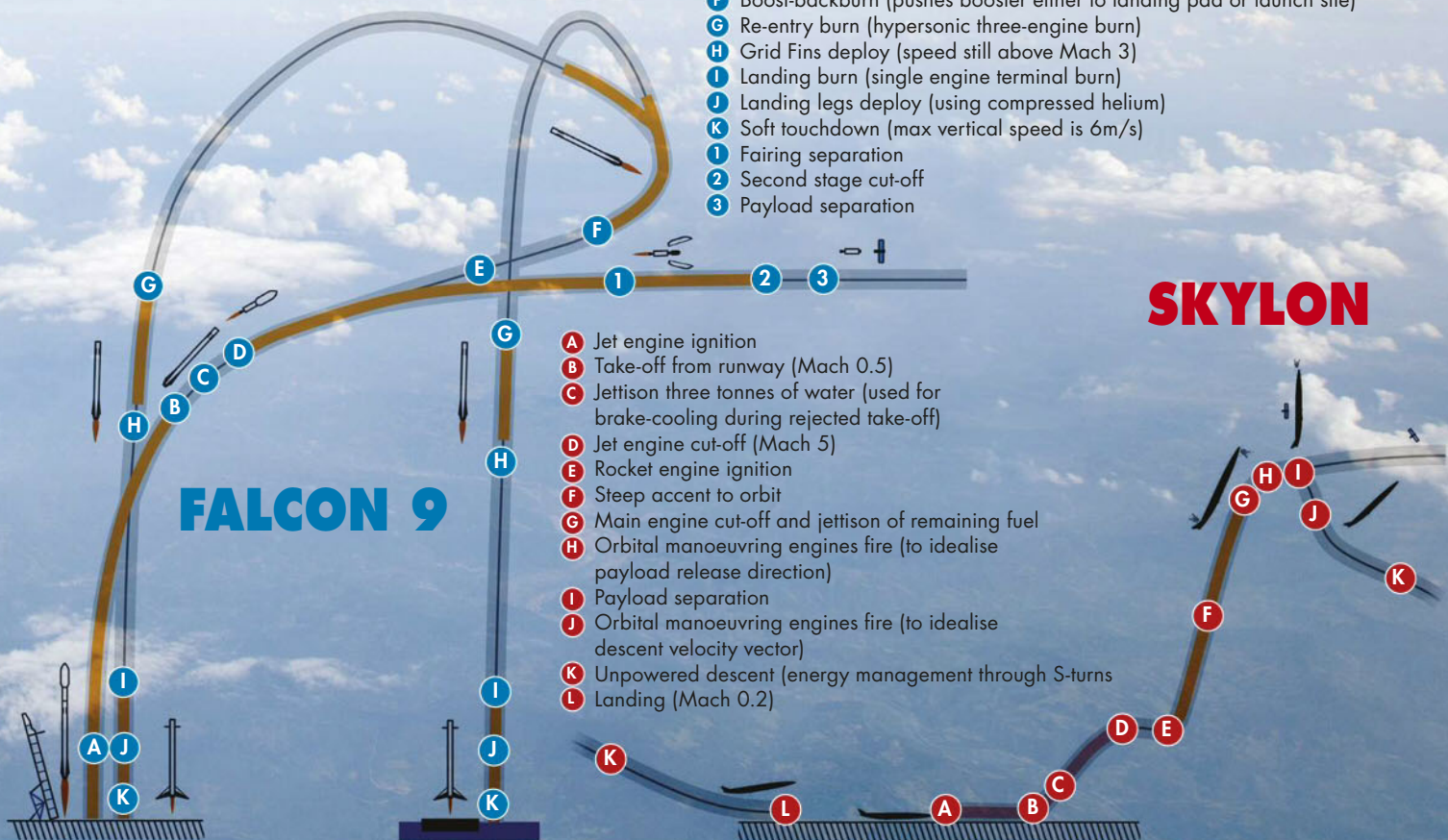
If spaceplanes do prove more reliable than reusable rockets, and with a life-expectancy approximately 20 times greater, spaceplanes could be the default for transporting manned and very precious cargo. Unless their reliability drops significantly first stage reusable rockets seem the logical choice for regular space cargo transportation. In future, both methods of spaceflight could exist side by side servicing different markets. **S**

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# LAUNCH PROFILES

A reusable vehicle's path to and from space is a set of precision gravity-beating manoeuvres

- A Liftoff from launch site
- B Main engine cut-off
- C Stage separation
- D Second stage ignition
- E Booster flips over (with nitrogen thrusters)
- F Boost-backburn (pushes booster either to landing pad or launch site)
- G Re-entry burn (hypersonic three-engine burn)
- H Grid Fins deploy (speed still above Mach 3)
- I Landing burn (single engine terminal burn)
- J Landing legs deploy (using compressed helium)
- K Soft touchdown (max vertical speed is 6m/s)
- 1 Fairing separation
- 2 Second stage cut-off
- 3 Payload separation





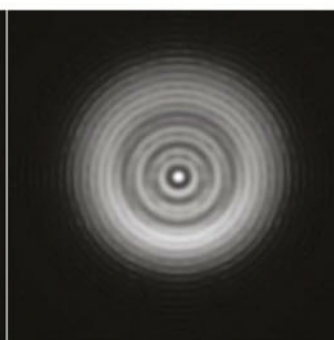
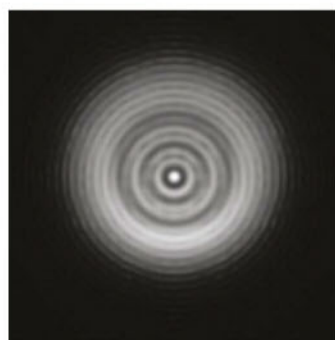
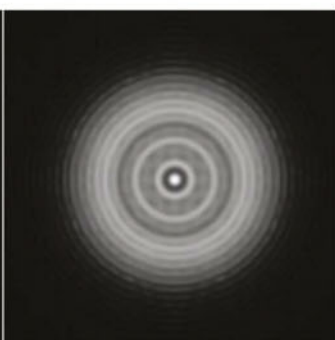
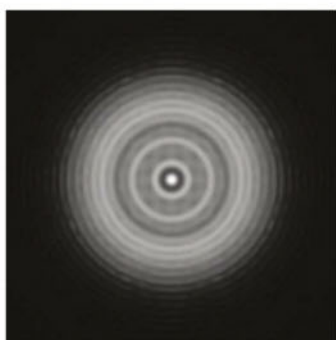
## The Guide

### Understanding optical aberrations

With **Steve Richards**

## PART 1

Learn how to identify the errors that can occur in your telescope's optics



▲ A simulated perfect Airy disk, appearing as a series of concentric rings

▲ Examining the rings can reveal aberrations; these ones show coma

**T**elescopes work by collecting light and then bending the rays to bring them to focus at the eyepiece or camera sensor, at

a point known as the focal plane. The very action of bending the light introduces unwanted aberrations, and although modern telescope designs produce

amazing results, they will always exist to some extent simply through the laws of physics.

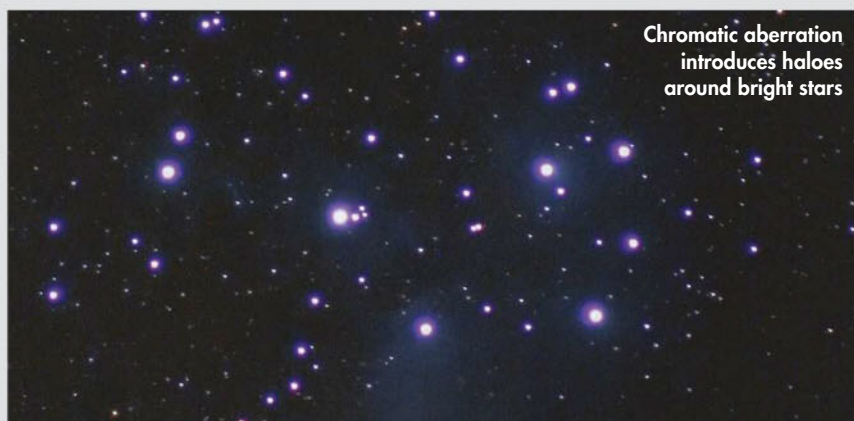
It's the telescope optician's job to minimise these aberrations as far as possible to produce a bright, high-fidelity view. Though some aberrations are barely visible when observing they become apparent once a camera is introduced, which is why we look for them in our *First light* reviews.

There are essentially two methods of bending the light from distant objects: by refraction through lenses and by reflection from the surface of mirrors. Each method produces a range of aberrations, although some are common to both types.

Some aberrations can be seen during a star test, which is a process in which a bright star is examined out of focus and at high magnification – we show you how to do this in this month's *How To*. Such a star will show an enlarged Airy disk and close examination on either side of correct focus can reveal much about the quality of the optics by noting the formation of the concentric rings formed in the image.

This month, we'll explain what causes three of the most common aberrations found in amateur telescopes; in part two, we'll look at a few more and give some advice on how they can be corrected.

Steve Richards is a keen astro imager and astronomy equipment expert



Chromatic aberration introduces haloes around bright stars

## △ CHROMATIC ABERRATION

**Affects:** Refractors, especially achromats, but can be mildly present in apochromats

The glass lens elements in a refractor are unable to focus all the colours of light at the exact same position because the refractive index of glass varies with the wavelength of the light passing through it, resulting in colour fringing. This shows as a blue halo around bright stars and as a yellow and blue colour cast to the opposite edges of the Moon and planets.

The effect can be minimised in scopes that use two glass elements made from different types of glass (historically crown and flint glass). This design, known as an achromat, brings

red and blue light to the same point of focus, but colours in between these two wavelength extremes still focus at a slightly different point. Chromatic aberration also decreases with an increase in the focal length. The inclusion of extra-low dispersion (ED) glass elements can also deliver very good results.

There is also a more complex design called an apochromat that is specifically designed to bring all the wavelengths of visible light to the same point of focus, resulting in high-quality images. It uses three glass elements, one of which is commonly made from ED glass.



Field curvature can result in stars at the edge of images being blurred, as seen in this cropped corner of a frame

## △ FIELD CURVATURE

**Affects:** All telescope designs

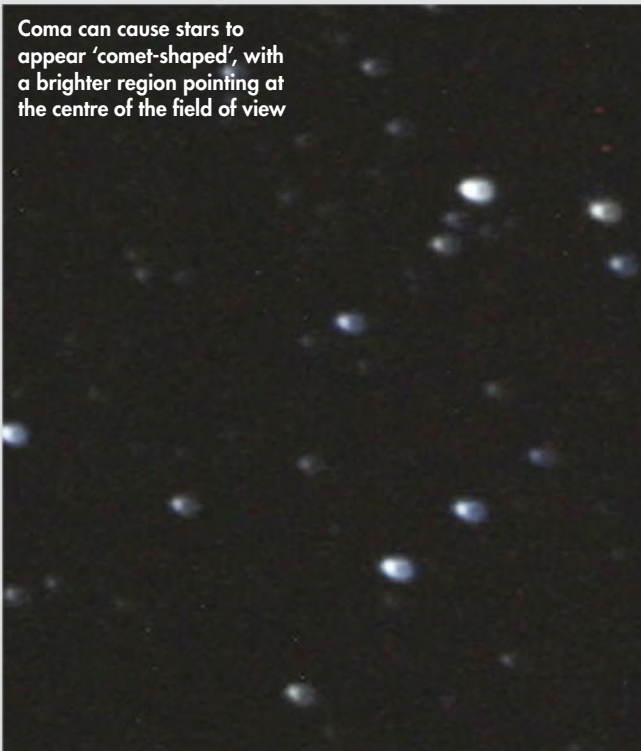
Curved surfaces are employed to bend light in both refractors and reflectors, and this results in a curved focal plane where objects at the centre of the field of view are in focus on the camera's sensor but those further out from the centre, known as off-axis, are out of focus. This is not such a big issue with

observing as the eyepiece and the eye itself compensate to a large extent. However, the flat surface of a camera's sensor is unforgiving and photographic images will clearly show off-axis stars as being out of focus.

Short focal length telescopes – especially Newtonian reflectors – exacerbate this

problem, but field curvature is present in most telescopes to some extent. The exception to this is with refractors employing an optical design known as a 'Petzval', in which there are four lens elements, the front pair correcting chromatic aberration and the rear pair correcting field curvature.

Coma can cause stars to appear 'comet-shaped', with a brighter region pointing at the centre of the field of view



## ◁ COMA

**Affects:** Predominantly Newtonians, but also Schmidt-Cassegrains and Maksutov-Cassegrains

Coma is an aberration that occurs predominately in reflectors and manifests itself in the appearance of 'comet-shaped' stars with their brightest portion pointing towards the centre of the field of view. Though not too obvious when observing through an eyepiece, coma becomes quite intrusive in images, especially when a large sensor is in use.

Just as with field curvature, coma becomes worse with shorter focal length telescopes. Coma increases with distance from the centre of the mirror, which means that the aberration affects off-axis light.

There are two main types of primary mirrors used in Newtonian telescopes: lower cost spherical mirrors, which form part of a sphere and are supplied with

low-budget telescopes, and the more popular parabolic mirrors, which are sculpted into the shape of a parabola. Spherical mirrors are standard in Schmidt- and Maksutov-Cassegrains but are largely corrected by the front corrector plate/meniscus lens.

Spherical mirrors suffer from spherical aberration in which light falling toward the edges of the mirror is focused at a different point to light falling closer to the centre. This means that with the exception of very long focal length telescopes, they are unable to focus the whole field of view at the same plane.

A parabolic mirror focuses light from across its surface at the same plane but unfortunately, there is a trade-off here and this design introduces coma. **S**



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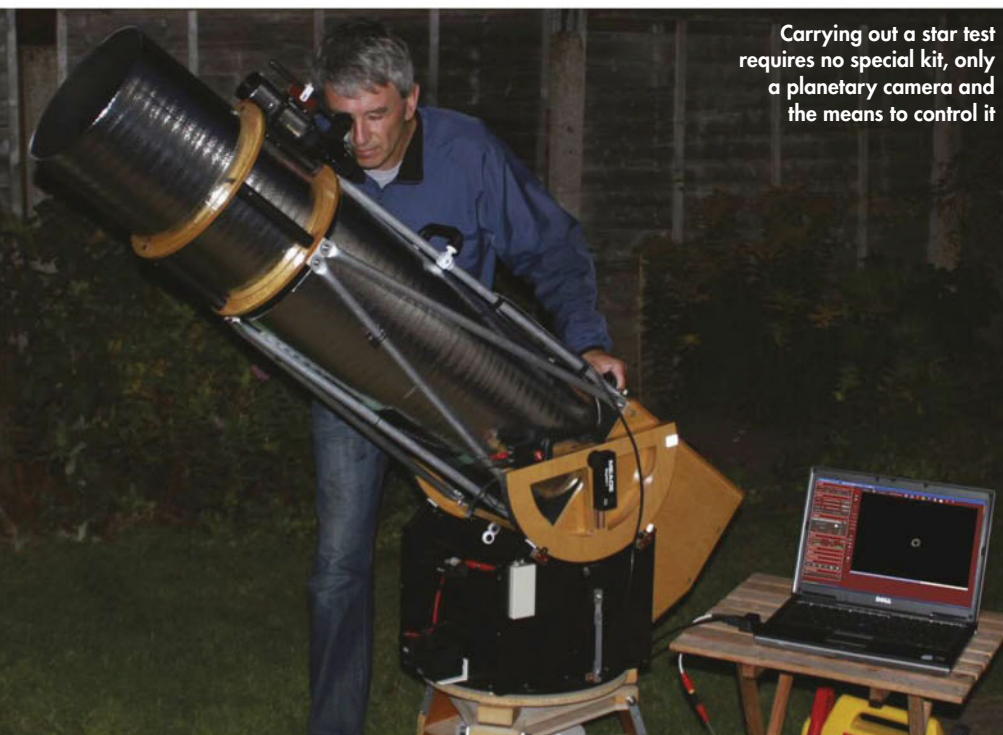


With Martin Lewis

# How to

## Use a video camera for star tests

Looking at a star can help you to identify flaws in your optics



## TOOLS AND MATERIALS

### CAMERA

Use a good digital video camera, such as you would for imaging the planets. For short focus telescopes, cameras with small pixels are especially useful – they give detail in the out of focus image for a small amount of defocusing, without the extra complication of using a Barlow lens.

### COMPUTER AND SOFTWARE

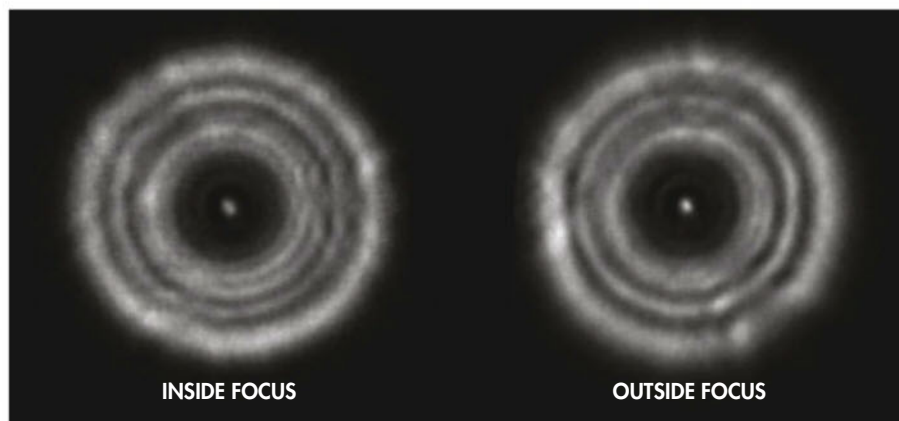
You'll need a computer installed with software to control your camera and record the star test images.

### SUNDRIES

A plastic ruler to match the image sizes either side of focus without scratching your screen

### REFERENCES

Star Test reference images can be found online or in books. Your own reference images can be made using the free program Aberrator (<http://aberrator.astronomy.net>).



▲ With perfect optics, the rings should look the same at the same point inside and outside focus

There is a deceptively simple test for determining the quality of the optics in your telescope: it is to simply look at an out of focus star. Stars are point sources of light, but if you defocus a star its image will expand into a series of bright and dark rings. The particular type of scope you have will determine the exact appearance of this expanded image but – importantly – if the optics are perfect this pattern will look exactly the same

inside of the focus point as it does the same distance outside of it.

The method is known as the 'star test', and you can use a Solar System digital video camera to help make it better and easier. It is a critical test of optical quality and it is quite usual for even well-performing telescopes to show noticeable differences either side of focus. The good news is that you can use the appearance of the out of focus images to help you understand the problem that your scope

may be suffering from, and often as not the issues are correctable – it may just be an issue of their correct optical alignment, temperature differences in the tube itself or even the atmosphere you are looking through.

Many sources of help exist in the interpretation of star test images as there are many possible variations in the ►

► appearance, such as the telescope design and the exact issue or combination of issues affecting it. *Star Testing Astronomical Telescopes* by H R Suiter is the definitive book on the subject and a very useful online summary with example star images is given at [www.willbell.com/tm/tm5.htm](http://www.willbell.com/tm/tm5.htm).

What you also need is an accurate record of your out of focus images that you can compare with the book or online images. Memory is unreliable, while making sketches relies on the atmosphere being very steady so that the out of focus image is stable enough for you to see the pattern clearly. You may wait weeks or months for such a night – and what a waste to use it for testing your telescope rather than observing.

## Why video triumphs

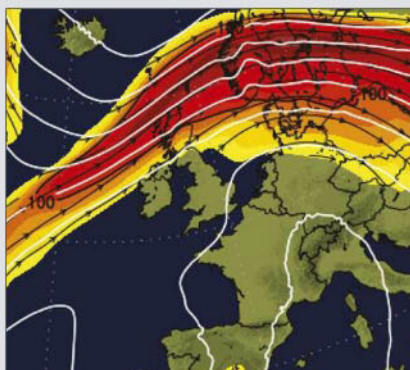
A much better method to make a useful record involves using a digital video camera, the sort you might commonly use for taking planetary images. In this method you capture a stream of individual short-exposure frames of the out of focus star, one video inside of focus and another video outside of focus. You can then use stacking software to sort the captured frames by quality and reject the ones most blurred by the atmosphere – just as if you were processing a planetary video. By aligning and stacking the good frames, you are left with an averaged frame relatively unaffected by the passage of the light through the atmosphere. This good frame can then be further processed using wavelets in RegiStax (see page 84) to bring out the details of the defocused pattern of rings. This way you don't need to wait weeks for that night of exceptional seeing – most reasonable nights will allow you to produce a good record of a star for comparison with references.

If you can, record the out of focus star without the use of any Barlow lens or eyepiece projection to get images generated by the bare optics. This is important as Barlows and eyepieces often introduce significant optical errors that can be seen in the out of focus star image.

Once you have your inside and outside focus images, compare them with each other. If they are identical then you have a rare thing – a perfect telescope. Most likely they will be different from each other and then you can compare the pair with images in books or online which will advise you as to the issue that might be affecting your telescope and what you might be able to do about it. **S**

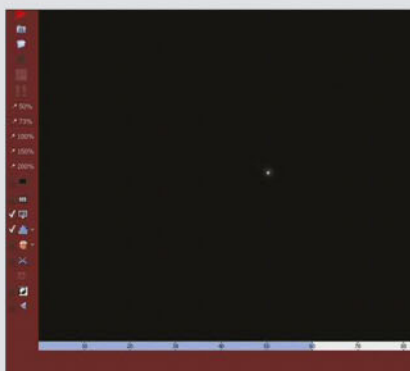
Martin Lewis is a keen astronomer and regular *First Light* reviewer

## STEP-BY-STEP GUIDE



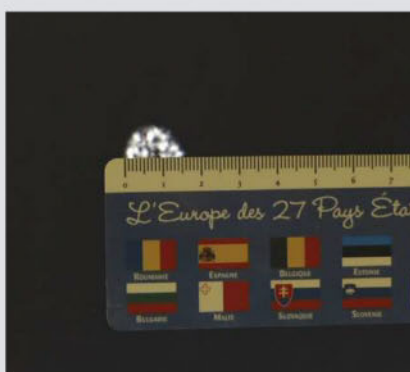
### STEP 1

Pick a night of reasonable seeing, when the jetstream is not overhead. Also avoid nights after a cold front has gone through. Allow your scope sufficient time outdoors to cool properly so that most of the thermal currents inside it die out.



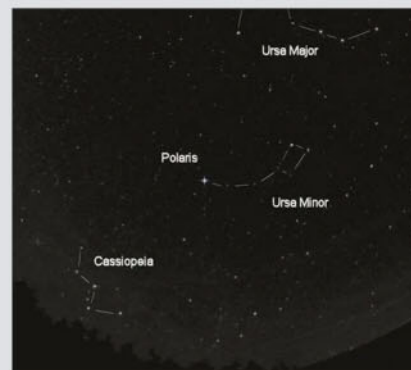
### STEP 3

Insert your camera and view the star on the preview screen using your preferred camera control software. Focus the image on the screen. Adding of a red or green filter in front of the camera will improve contrast.



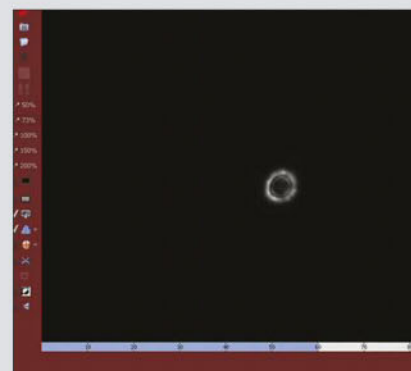
### STEP 5

Defocus the image outside of focus so that the overall ring structure is about the same size as the previous one. With the same preview zoom level, use a ruler on the screen to check it is the same size, then image it as you did in Step 3.



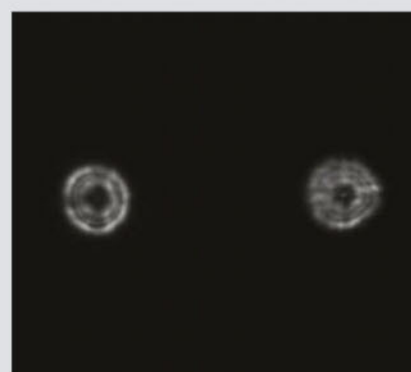
### STEP 2

Now you need to pick a star: choose one at a high altitude, where the seeing is better. Polaris works particularly well for undriven scopes from the UK as it will be at least 50° high and will remain almost stationary during the test.



### STEP 4

Rack the focuser inside of the focus point to expand the star into a pattern of rings. Alter the exposure and focus so you can see five to 10 rings in the image. Record a video of one minute so you have several hundred frames to average.



### STEP 6

Stack the images using a registration and stacking program such as RegiStax or Autostakkert, and apply a little sharpening. Compare the pair of inside focus and outside focus images with each other, and also with reference images found in books or online.

# UNIVERSITY OF YORK



The Centre for Lifelong Learning at the University of York has just launched its postgraduate diploma in astronomy, delivered online via distance learning and led by Dr Alex Brown. Bringing together students from across the globe to explore the shared wonder of the night sky, the programme will aim to give students a solid foundation of knowledge which will allow them to undertake their own research. We'll explore radio astronomy through the infra-red and into the visible before travelling to ever-increasing energies of radiation to x-rays and gamma-rays, before concluding with neutrino, cosmic ray and gravity wave astronomy – time will also be spent considering the lives and deaths of stars. This exciting two-year, part-time programme starts in late September every year, and is aimed at home astronomers and the academically inclined. Applications are being taken now.

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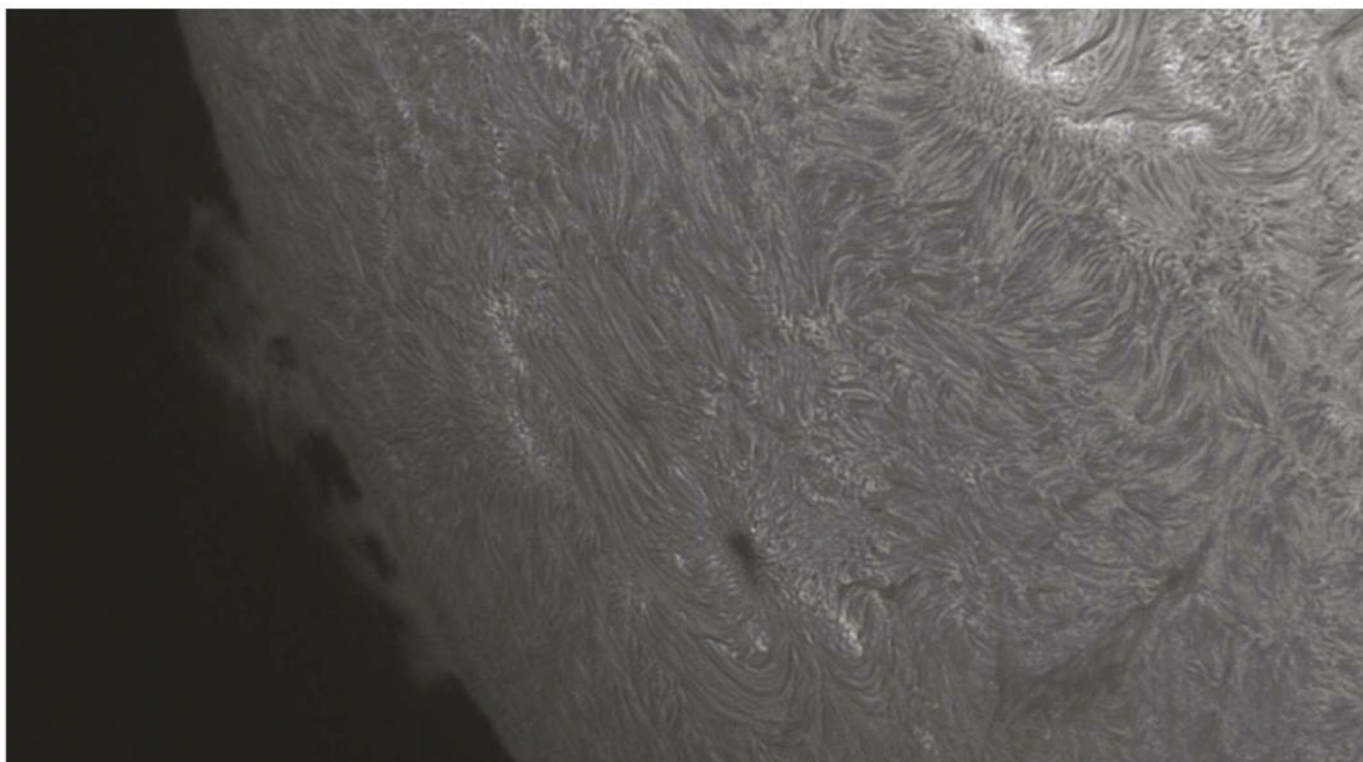
**[www.york.ac.uk/lifelonglearning/astronomy](http://www.york.ac.uk/lifelonglearning/astronomy)**



With Gary Palmer

# Image PROCESSING

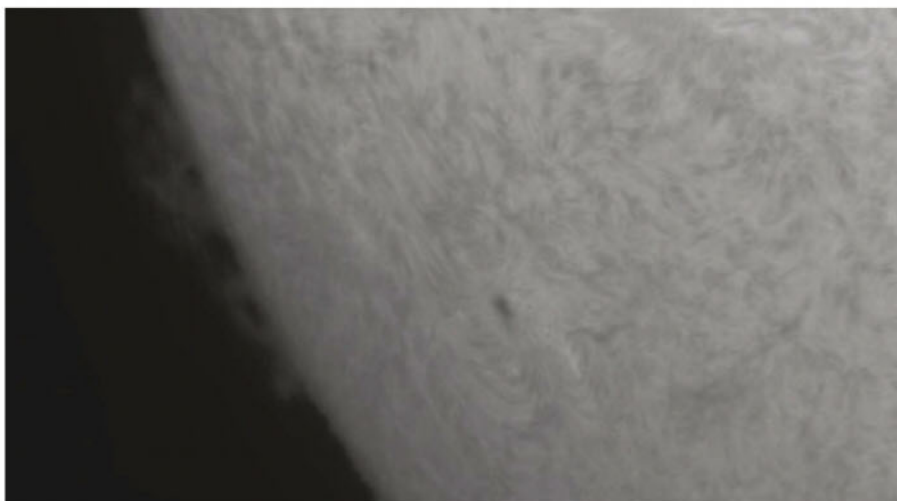
## Understanding and using wavelets in RegiStax



▲ Our final, wavelet-processed shot of the Sun possesses a great deal more detail and contrast than our starting image, shown below

**R**egiStax has a very powerful wavelet processing section that can help you to reveal lots of hidden data in images after they have been stacked. You don't have to use RegiStax to stack your frames in the first place though, as several stacking programmes that don't have a wavelets option can send their output directly into it, so long as you already have RegiStax open. With the right wavelets processing, you can bring your images alive with stunning detail that otherwise would remain hidden.

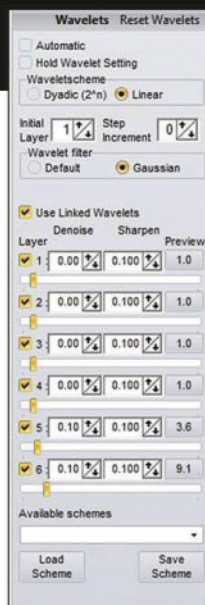
The controls for wavelets can look a little confusing to start with, but they are quite easy to use. Each of the sliders (shown at the top of the opposite page) on the left-hand side is a layer of the picture. Imagine that you have six pictures on separate pieces of paper, all on top of each other – this is how the image looks when it



▲ Our initial image of the solar surface – prior to wavelet sharpening it looks a little blurry

is first loaded. So when we adjust layer two, it would bring detail from the second piece of paper through to the top of the image. For layers farther down, the detail

they bring through can be quite coarse. You need to be quite gentle when adjusting as you can make your image look over processed, or introduce noise to the image



◀ RegiStax's wavelet control panel looks complicated but is simple to use

► Here we have been overzealous with the adjustments, resulting in an over-processed image

and make it look grainy. This can happen very easily

if you are processing a lower-resolution image taken with a small telescope.

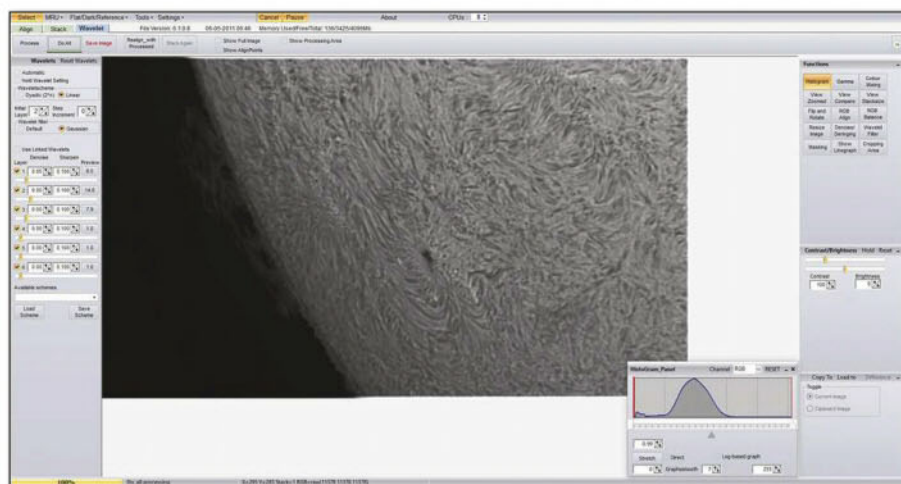
The check boxes on the left side will have different effects on all sorts of images. There is no set rule as it is dependent on a lot of factors, such as seeing conditions at the time of capture and the amount of frames that were stacked. What works for one image might not work for another. As a general guide, set the Wavelet Scheme to Linear and the Wavelet Filter to Gaussian as this allows greater control over the processing. Opting for the Default Wavelet Scheme can be used with good results, but allows no control over the amount of noise introduced to the image.

## Subtle sharpening

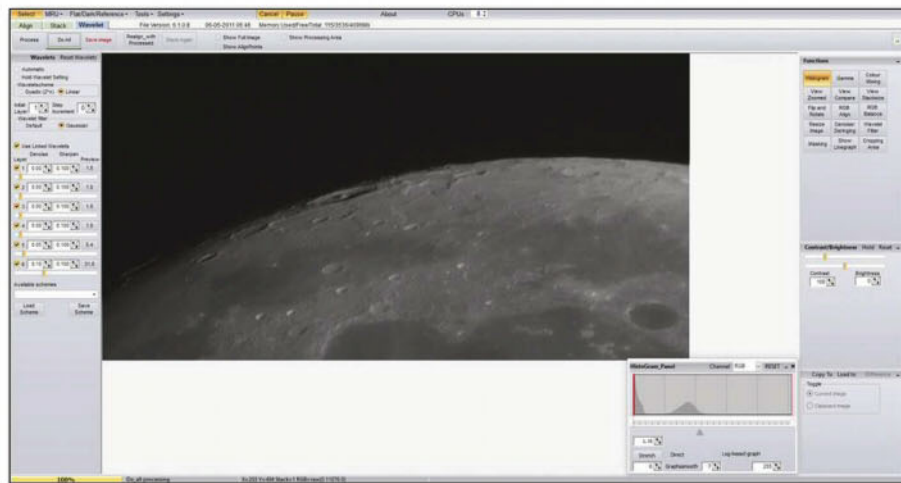
When your image first loads into RegiStax it can look quite bland and blurry. If your image is a little dark when loaded, look to the Functions tab on the right-hand side of the program and click Histogram. Adjust the middle slider to the left to brighten the image. This will help you to see what is happening as you make adjustments. The image may start to look over processed because the tab marked Initial Layer is on number 2. In short, this doubles the strength of sliders and in most images it is a good idea to have this on 1 to start with. The Step Increment should be set to 0.

Double click over an area of interest in the image. This will activate the adjustment preview to that area. Layer 1 can add the most noise to an image, so to start click on Layer 2 and drag it to the right. When it is released you will start to see the changes to the image. You can then do the same with Layer 3. If you see very little change to the image change Initial Layer back to 2 and repeat.

Above the slider for each layer is a box marked Denoise. This can be used to control noise introduced with the



▲ Gentler adjustments will help you to end up with a much more natural look



▲ 'Linked' wavelets can be useful for bringing fine detail out of lunar surface shots

wavelet sharpening. In Layer 1, click the up arrow in the Denoise box so it shows 0.05. Over adjustment may start to make your image look blurred so gentle adjustments are needed.

Linked wavelets can be good for images of the Moon that require fine detail. This technique works by linking all of the layers together. At the top click the Reset Wavelets tab, then the Linked Wavelet tab on the left above the sliders. Using the

slider in just Layer 1 or Layer 6 will bring out detail from all the layers. You will only need a gentle adjustment using this, but quite often it will need a Denoise setting of 0.15 in the adjustment layer. When you are happy click the Do All tab to see the adjustments to the whole image. S

Gary Palmer is an expert solar imager. See more of his shots at [www.solarsystemimaging.co.uk](http://www.solarsystemimaging.co.uk)

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With **Steve Richards**

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The Harp in Lyra, after its component stars have been enhanced; this can help asterisms stand out in starry shots

## What is the best way to bring out asterisms in my star field images?

PATRICIA ALEXANDER

An asterism is a collection of stars that form a recognisable shape in the night sky, sometimes representing a significant part of a constellation, although the individual component stars are not necessarily connected to one another and may be from different constellations. Well known asterisms include the Plough in Ursa Major, the Teapot in Sagittarius, the Harp in Lyra and the Summer Triangle, which spans Lyra, Cygnus and Aquila.

The bright stars of asterisms make them stand out when observed with the naked eye or through binoculars, but in images with starry backgrounds – such as those asterisms that have the Milky Way as a backdrop – they can lose some of their grandeur.

Fortunately, image processing can bring some of this back and although there are several ways of simply brightening specific stars in an image, a more attractive method is to both brighten and increase the colour saturation of the prominent stars. Astrophotographer Noel Carboni is well known for his image processing action set, but he has also created a (paid) Photoshop plug-in called StarSpikes Pro that can add artificial diffraction spikes to star images. In addition to the introduction of diffraction spikes, it can also be adjusted to produce a soft flare on bright stars, and it is this feature that can be put to use to enhance asterism stars.

## STEVE'S TOP TIP

**How can I estimate angular distance on the sky?**

Estimating the angular separation of celestial objects is a very useful skill for locating objects to observe and it's easy to do by simply holding your hand at arm's length! Clench your fist and the width of your hand will be approximately 10°. If you now extend your little finger and thumb outwards, from tip to tip will be about 25°. Extending your little finger and index finger in the same manner will yield 15° and your ring, middle and index fingers pressed together approximate to 5°. Finally, holding up just your little finger gets a good approximation of 1°. See our *Dark Skies Survival Guide* on page 33 for more details



**How do I know whether my mirror needs recoating, and how do I go about it?**

SCOTT JACKSON

The mirror surface of most reflecting telescopes can remain usable for decades, but so much depends on the coatings applied, the conditions in which the telescope is used and how it is stored. Telescope mirrors will work well even with the inevitable coating of dust that they will acquire over time so this should not be of any concern. Moisture, however, can cause long-term damage.

The effects of dew should be alleviated by allowing the telescope to dry out indoors after each session and you should avoid storing the telescope in a damp location at all costs as this will dramatically reduce the life of the coatings.

As for telling when the mirrors will need to be recoated, you'll know because the surface will look so awful that the silvering will be flaking off! Companies such as Orion Optics, Oldham Optical, Vacuum Coatings and Galvoptics can complete the recoating for you.

Steve Richards is a keen astro imager and an astronomy equipment expert

Email your queries to [scopedoctor@skyatnightmagazine.com](mailto:scopedoctor@skyatnightmagazine.com)

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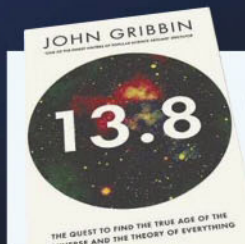
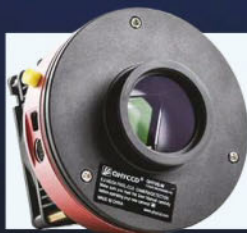
- ★★★★★ Outstanding
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- ★★★★☆ Good
- ★★★★☆ Average
- ★★★★★ Poor/Avoid



90

This AiryLab hydrogen-alpha scope offers a large aperture for solar work

## This month's reviews



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**94** Baader Nano Tracker travelling mount

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# FIRST light

See an interactive 360° model of this scope at [www.skyatnightmagazine.com/AirylabHaT](http://www.skyatnightmagazine.com/AirylabHaT)



## Airylab 203mm Hydrogen-Alpha Chromosphere Telescope

An invigorating approach to upgrading a solar setup

WORDS: PETE LAWRENCE

### VITAL STATS

- **Price** €4,400
- **Optics** Celestron EdgeHD
- **Aperture** 203mm (8 inches)
- **Focal length** 2,032mm (f/10)
- **Focuser** Standard Schmidt-Cassegrain with 100-250mm backfocus at better than one-quarter wavelength performance
- **Extras** 2.7x telecentric amplifier, Schmidt-Cassegrain thread to 31.75mm adaptor
- **Weight** Telescope 6.35kg, telecentric amplifier 0.55kg
- **Supplier** Altair Astro
- **www.altairastro.com**
- **Tel** 01263 731505

**A**perture fever describes when someone has a burning desire to increase the light-gathering power of their telescope. For night-time instruments, larger apertures mean more light collection, but it is even more valuable for solar observing, as increased aperture also improves resolution, allowing finer detail to be seen.

Consequently, solar observers regularly get the desire to upsize too. However, upgrading to a large hydrogen-alpha setup can be very costly, certainly far more expensive than moving from a small night-time instrument to a large one.

The Airylab 203mm Ultra High Resolution Hydrogen-Alpha Chromosphere Telescope, or Airylab 'HaT', tackles this issue. It is a Celestron EdgeHD800 CG5 that has been modified to be a front end for a rear-mounted hydrogen-alpha filter. The filter is not included.

The HaT works optimally with the Daystar range of hydrogen-alpha filters up to a field diameter of 44mm. For our tests we mainly used a 0.6-Angstrom Daystar Quantum PE filter, but also tried it out with the less expensive Daystar Quark. A high-end filter will cost you several thousand pounds on top of the HaT, but the

Quark currently comes in at around £850. It's also possible to use the etalon from a Coronado PST or – with suitable neutral density filters – observe or image the Sun in white light through the HaT.

With the Quantum PE filter fitted, the HaT is an impressively simple system to use. It is lightweight, and the button-press tuning of the filter means that everything is kept at the eyepiece end of the scope where it's easy to reach. Of all the solar setups we've tested over the years it is among the easiest to use, despite the fact that it is aimed at serious solar observers.

### Seeing and the Sun

Our first efforts to view the Sun were a little blurry. Like all Schmidt-Cassegrains, the HaT can go out of collimation, something we confirmed by observing an almost full Moon. We decided to recollimate using a star. Finding one through the coated corrector without a finder initially proved bothersome – though ▶

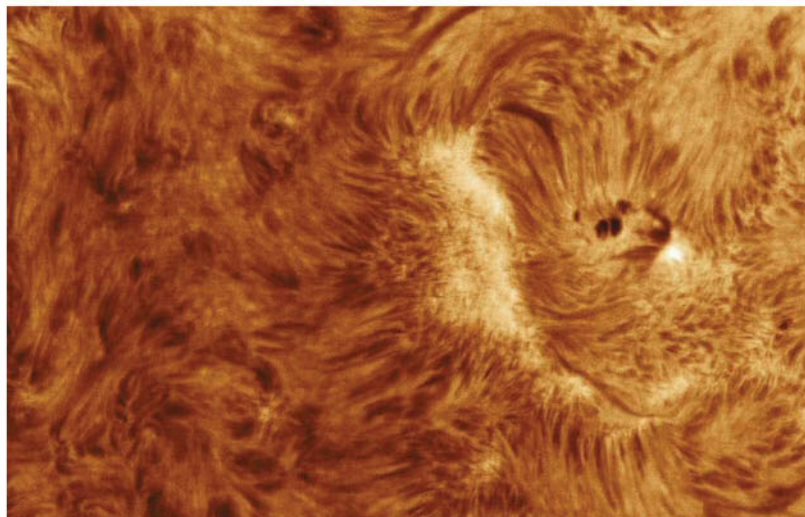
### SKY SAYS...

Of all the solar setups we've tested over the years it is among the easiest to use

### A CURE FOR APERTURE FEVER

An 8-inch aperture hydrogen-alpha scope is something of a dream machine if you're into solar observing. Coupled with a suitable hydrogen-alpha filter, the Airylab HaT breaks the confines that have dogged solar observers and imagers for many years. Though other options are available, they tend to be large, heavy and expensive refractor-based solutions. The full aperture energy rejection filter-coated corrector on this scope has a 120nm bandpass (full width at half maximum) with a transmission of greater than 80 per cent at the hydrogen-alpha wavelength.

The extra resolution provided by the HaT's 8-inch aperture works best if the seeing is good to excellent. To make the most of good seeing, Airylab also offers an optional solar scintillation monitor, which attaches to the HaT and reports on the quality of the sky; with certain cameras, it can even automate imaging to only capture when the seeing gets good.



▲ The HaT offers high detail; here delicate plasma can be seen around a sunspot group

## COATED CORRECTOR

The corrector plate is coated with a hardened dielectric layer. This layer, visually blue-green, provides the energy rejection filter properties that make it safe to point the scope at the Sun. The filter's red transmission also means you can use this scope for red-filter planetary imaging or recording long exposures of the deep-sky in hydrogen-alpha.



## SECONDARY COVER

The HaT has a simple but effective slip-on white plastic cap fitted over the secondary housing to help keep the normally dark assembly cool while pointed at the Sun.

The cap did turn out to be a little loose though, and had to be pushed back on frequently.

## CELESTRON EDGEHD TELESCOPE

The AiryLab solar modifications are made to a standard Celestron EdgeHD800 CG5 8-inch – and its 9.25-inch and 11-inch cousins can be modded too. According to AiryLab, particular instruments are benchmark tested for better than one-quarter wavelength performance at the 635nm wavelength. This means that the telescopes are optimally suited for high-resolution hydrogen-alpha solar work.



## CELESTRON CGE DOVETAIL

The standard EdgeHD800 comes with a Celestron CGE dovetail that will fit Celestron CGEM, CGEM DX and CGEM Pro mounts. The dovetail is also Losmandy compatible, a standard fitting found on many high-end mounts. As the 8-inch EdgeHD is quite light, you shouldn't have trouble using it on most mid-range mounts.

# FIRST light

## 2.7x TELECENTRIC AMPLIFIER

The converging rays coming from the telescope need to be virtually parallel when they enter a rear-mounted hydrogen-alpha filter etalon. This is achieved by fitting the custom-designed telecentric amplifier between the scope and etalon. The amplifier increases the effective focal length by 2.759x – in this case 5.6m.



### SKY SAYS...

Now add these:

1. iOptron Minitower mount
2. Daystar Quantum hydrogen-alpha filter
3. Airylab solar seeing monitor

► we did manage it. We then fitted the supplied 2.7x telecentric amplifier and tweaked the collimation again to get it perfect.

The next day we had another go and the story was completely different. Now, despite mediocre seeing, we saw what all the fuss was about. Active regions showed superb fine detail, which we were also able to record in our images. The setup was fantastic on the chromosphere and for prominences alike. Again, we witnessed tantalisingly fine detail in these huge features as they extended off the edge of the Sun. A minor gripe is the lack of fine focusing, the standard Schmidt-Cassegrain focuser of the EdgeHD800

being a little coarse for high-resolution observing. The chromosphere is a blanket layer of hydrogen covering the Sun's visible surface to a depth of several thousand kilometres. Seen at the edge of the Sun, it takes on an appearance that looks like fine fur. The high-resolution capabilities of the HαT revealed the spicules, or jets of gas, that create this impression really well.

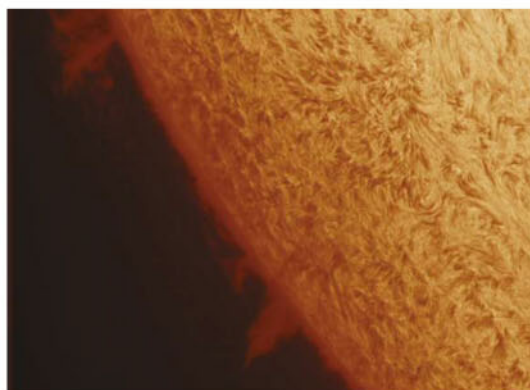
## Scaling for success

The telecentric amplifier mentioned above increases the effective focal length of the scope to around 5.6m. This gave us an image scale that was magnified but still relatively easy to work with. The contrast of the view looked low compared to other systems we've used but this is fairly easy to correct when imaging.

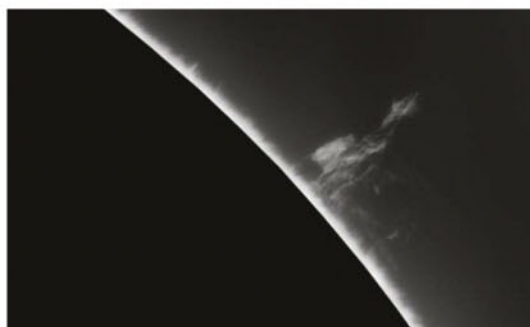
Delighted with the results we got with the Daystar Quantum PE, we decided to replace it with the less expensive chromosphere optimised Daystar Quark. This has its own 4x amplifier built-in so we didn't use the telecentric amplifier supplied with the HαT. Here the extra amplification pushed things a little too high for our observing conditions but it has to be said that this also produced reasonable results.

As with any large aperture telescope, the key to obtaining the best results is to use the scope when the seeing is good. Sadly in the UK this can take a long time to occur but when it does, the Airylab HαT can prove itself to be worth every hard earned penny spent on it. It can reward you with views of the Sun that will take your breath away. **S**

► A single shot of the edge of the Sun showing a 'filaprom'. The atmospheric seeing wasn't very steady but the HαT still managed to bring out some good spicule detail at the Sun's edge



► This monochrome shot of a small prominence show lots of fine detail as well as the spiky nature of edge-on chromosphere caused by spicules; note the solar disc has been artificially masked



## VERDICT

BUILD & DESIGN	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
IMAGING QUALITY	★★★★★
VISUAL QUALITY	★★★★★
OVERALL	★★★★★

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# FIRST light

See an interactive 360° model of this mount at [www.skyatnightmagazine.com/BaaderNano](http://www.skyatnightmagazine.com/BaaderNano)



# Baader Nano Tracker travelling mount

A pocket-sized mount perfect for simple DSLR astrophotography

WORDS: PAUL MONEY

## VITAL STATS

- **Price** £199
- **Payload capacity** 2kg
- **Tracking rates** Sidereal, half-sidereal, lunar and solar; northern and southern hemisphere
- **Polarscope** Zero-magnification sight hole
- **Power requirements** Three AA batteries or external power via mini USB (5V, 0.5A)
- **Battery life** Five hours
- **Weight** Tracker 400g; hand controller 80g (without batteries)
- **Dimensions** Tracker 60x98x44mm; hand controller 50x105x22mm
- **Supplier** David Hinds
- **www** celestron.uk.com
- **Tel** 01525 852696

## SKY SAYS...

For such a small system there is little fuss and it will make DSLR astrophotography a lot of fun

Portable, easy to use and easy to set up tracking mounts have become fashionable in the past few years and almost all are designed for DSLRs attached to large lenses or small telescopes. But what if you only want something to allow your camera to track the stars without it being too heavy or cumbersome? Baader Planetarium has introduced its Nano Tracker mount to Europe. It is made in Japan by Sightron, which has been marketing it under its own name in the Far East. This incredibly small, lightweight and easy to use mount may well be just the thing to take away on holiday for some wide-field DSLR imaging.

The Nano Tracker comes as two parts, the actual tracking module and a separate hand controller. Together they weigh just 480g without batteries and can fit in hand luggage comfortably without taking up much space at all. You will also need a tripod and a ball head to attach a DSLR. The tracking module attaches to a standard tripod with a 0.25-inch photo-thread, while another 0.25-inch photo-thread on the top side allows you to attach a ball and socket head. Its load capacity is up to 2kg so it could easily take, say, a Canon EOS 50D DSLR with its EF 18-55mm lens.

The tracking module also has an integrated polar sighting hole to help you align with Earth's axis for proper tracking, although we did find that it was difficult viewing through it when we attached the module to our tripod. Baader suggests attaching a ball head to the tripod,

then the tracker and then adding another ball head before the camera to provide clearance for using the sight hole.

## Power in your palm

The hand controller is powered by three AA batteries or via a mini USB port. The controller's cable slots into the socket on the tracking module and also features a strap so you can attach it to a tripod. Press the central button on the controller and it automatically starts up in sidereal mode. The mount can be also set to half sidereal, lunar and solar tracking speeds, and there is a slide to set northern or southern hemisphere. Note that the 'speed' slider only has 1x and 0.5x stops; lunar and solar speeds have to be set by sliding them in conjunction with the northern/southern hemisphere slider. The manual has full instructions on how to do this. A blinking green light indicates your choice of tracking mode – it would have been nice if this was a red light. ▶

## INCREDIBLY LIGHTWEIGHT AND PORTABLE

The Nano Tracker has to be the smallest and lightest tracking unit on the market. Its dimensions are a measly 60x98x44mm, whilst the hand controller is only 50x105x22mm. Individually, they fit into the palm of your hand quite nicely. Together, and without batteries in the hand controller, they weigh 480g – so

incredibly unlikely to tax your hand luggage allowance if you want to take it abroad with you. We found it easy to hang the controller on our tripod so it was within easy reach, although once the module was tracking we didn't need to change anything.

For such a small system there is little fuss and it will make astrophotography with a DSLR a lot of fun if you only want to capture images of starry landscapes or wide-field views of the Milky Way. Added to this, it can also be used for timelapse photography. It really is a versatile little system.



## DRIVE

Considering the tracker module's size and lightness it is impressive how well integrated the stepper motor and steel-brass wheel gear are. You do need to hold the outer drive wheel firmly when attaching a ball head to ensure the teeth are not stripped when tightening it in place.

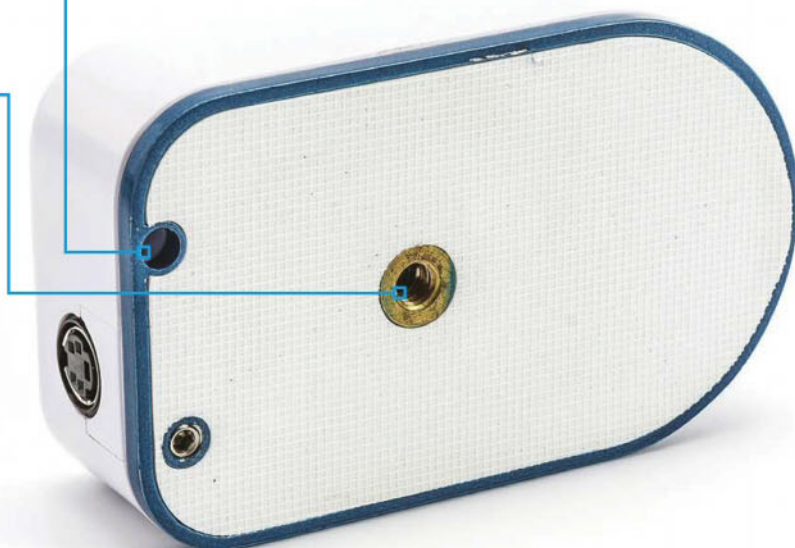


## POLARSCOPE

Polar alignment is vital for good tracking and the Nano Tracker has an integrated zero-magnification sight hole, which is useful for the sighting on Polaris. Some tripod heads may lie a little close to it, so a second ball head is useful to give more space for looking up through the sight hole.

## TRACKING MODULE

The tracking module houses the gear system and stepper motors, has the 0.25-inch threaded screw for attaching a ball head and camera on the top and a 0.25-inch thread for attaching the module to a tripod. A sight hole and hand controller socket completes the module, although there is an additional port not mentioned in the instructions.



# FIRST light

► Using the mount in combination with our Slik tripod, Canon EOS 50D DSLR and an 18-55mm lens, we polar aligned then took a range of images. With the lens set at 55mm we found we could achieve good pinpoint stars with exposures up to two minutes, while five-minute, wide-angle shots at 18mm gave good results of the Milky Way and the Summer Triangle asterism. Stacking four such images then processing them brought out a wealth of detail.

We also tried a modded Canon 300D (which has better red sensitivity) with an 18-55mm lens set at 34mm to image Cygnus. After collecting 16 two-minute exposures at ISO 800 and processing, we were very pleased with the results. So much so that we swapped to our 70-300mm lens set at 70mm and took 14 one-minute exposures of the North America Nebula, and also the nebulosity around Sadr in Cygnus, with very gratifying results.

We were pleased with the Nano Tracker, but did feel that if the sight hole were situated a little farther out to give better clearance for users of most ordinary tripods it would help more with polar alignment. Better polar alignment will lead to longer exposures before trailing becomes apparent, however our test results were pleasing all the same. Such is this unit's small size and light weight that we can still recommend it heartily. **S**

## HAND CONTROLLER

On the front of the hand controller are two sliders and a simple power button. The left slider sets sidereal rate (1x) or half sidereal (0.5x), while the right slider offers northern or southern hemisphere selection.



▲ The bright star Deneb (Alpha Cygni) and the North America Nebula, imaged as 14 one-minute exposures taken with Canon EOS 300D DSLR and a 70-300mm lens



## POWER SUPPLY

The Nano Tracker requires three AA batteries, which slot into a compartment on the back of the hand controller. These can give power for up to five hours and in our tests we didn't need to change them. Power can also be supplied via a mini USB lead providing 5V, 0.5A power. This cable is not provided.

## SKY SAYS...

Now add these:

1. Celestron TrailSeeker Tripod
2. Ball head adaptor
3. Three AA batteries

## VERDICT

ASSEMBLY	★★★★★
BUILD & DESIGN	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
TRACKING ACCURACY	★★★★★
OVERALL	★★★★★



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# FIRST light

See an interactive 360° model of this camera at [www.skyatnightmagazine.com/QHY9S](http://www.skyatnightmagazine.com/QHY9S)



## QHY9S monochrome CCD camera

Great for beginners and those looking to upgrade from a DSLR

WORDS: STEVE RICHARDS

### SKY SAYS...

Images showed plenty of detail and fairly realistic colours despite the use of narrowband filters

### VITAL STATS

- **Price** £1,399
- **Sensor** KAF-8300 (17.9mm diagonal)
- **Pixels** 3,336x2,496 pixels (5.4µm square)
- **Backfocus** 15.5mm
- **Weight** 553g
- **Connectivity** USB 2.0, filter wheel control port
- **Extras** Software CD, rechargeable desiccant system
- **Supplier** Modern Astronomy
- **www.** [modernastronomy.com](http://modernastronomy.com)
- **Tel** 020 8763 9953

WWW.THESCREETSTUDIO.NET X6

**D**eep-sky imaging cameras come in all shapes and sizes; some have clearly had a lot of time and money spent on their aesthetics while others take a more down to Earth approach by concentrating more on function and less on form. However, all of them are designed with an apparently simple task in mind – to capture the dim light from celestial objects many lightyears away.

The QHY9S falls into the function over form category, although it is more robust in design than unattractive, something typified by its large and clunky looking cooling fan. The advantage of this approach to design is reflected in its relatively low price, but it still needs to perform well to appeal to imagers.

Supplied in a plain carton, the camera was well protected from damage in shipping. Its matt black and electric red body colours were well applied, although we've been informed the latest retail version of the camera will be all black. With a weight of 553g, the camera had a purposeful feel and it was simple to attach to the 2-inch filter wheel lent to us for the purpose of this review.

There is much debate in imaging circles over the filter size that can be used with the relatively

large KAF-8300 sensor used in this camera, to ensure that the filter edge doesn't cause vignetting of the image. Vignetting results in light fall-off towards the edges of the field of view and can occur when the light cone is constricted by a physical obstruction. For some camera designs that have a built-in filter wheel that places the filters very close to the sensor, 1.25-inch filters can be used, but the QHY9S requires 2-inch filters.

The CD supplied with the camera includes a user manual in PDF format, camera drivers, ASCOM drivers and two camera control programs, CCDCap and EZCap. All of the drivers loaded quickly and easily onto our computer. Although we tested the camera with both control programs, for the bulk of our review we chose to use the ASCOM driver via MaxIm DL for ease of integrating into our existing system. Both the QHY9S and the borrowed QHY filter wheel worked seamlessly with MaxIm DL.

### Cool under pressure

With the short summer nights, a tight schedule and a waxing Moon, we chose to image a HII region high overhead in Cygnus and settled on the Pelican Nebula. This emission nebula is rich in hydrogen-alpha (Ha) emissions although ▶

### AN UNUSUAL CHOICE OF SENSOR

The QHY9S employs an interesting choice of sensor, the monochrome KAF-8300. This sensor neatly bridges the gap between the smaller, Sony sensors and their larger and more expensive APS-C sized sensors (the same size as found in DSLR cameras), and the even larger 35mm film equivalent sensors. It has a total of 8.3 megapixels across its surface but its physical size allows for individual pixels of 5.4µm square to be used, producing high-resolution images without sacrificing sensitivity. The sensor is 17.9x13.5mm, yielding a 22.5mm diagonal size, with an array of 3,336x2,496 pixels. In a departure from more typical CCD sensors, the KAF-8300 is a full frame sensor, which means that it requires a mechanical shutter to exclude light during the image download process to avoid light smearing. Incorporating this mechanical shutter has caused problems for some manufacturers in the past but the simple mechanism in the QHY9S works quickly and efficiently despite the rather unusual noise that it makes at the end of its travel.





## CONNECTIONS

With the control circuitry housed in an external control module, the connections to the camera itself are few. A multi-pin connector provides separate power to both the camera/mechanical shutter and the cooling system. A USB 2.0 port for connection to a computer and a control port for the optional electronic filter wheel are also present.



## SET-POINT PELTIER COOLING

As well as the substantial cooling fan on the rear of the camera, there is a two-stage Peltier cooling system that will cool the sensor down to around 50°C below ambient temperature to reduce thermal noise. At an ambient temperature of 19.7°C, it took 130 seconds to reach a temperature of -20°C.

## POWER CONTROL MODULE

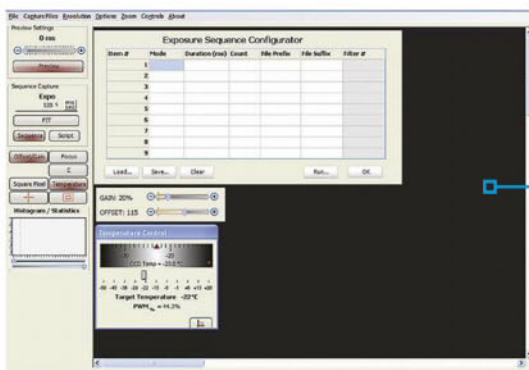
Unusually, the QHY9S has much of its electronic circuitry in a remote electronic power module. The thinking behind this is to keep extraneous electronic noise away from the sensor. We found this to be a useful feature with convenient LED lights confirming supply voltage, fan activation and Peltier cooling in operation.



# FIRST light

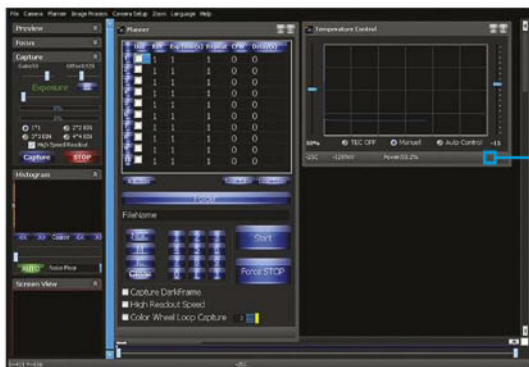
## MOISTURE CONTROL

The sensor is mounted in a fully sealed chamber with a heated cover glass to exclude dust and moisture. This chamber has two purge ports for replacing the chamber gas if required, and an external rechargeable desiccant cylinder can be attached to one of the purge ports to extract any moisture from inside the chamber.



## CAMERA CONTROL SOFTWARE

Two control programs (CCDCap and EZCap) are supplied with the camera and these provide uncomplicated graphical interfaces for all aspects of operation. A simple sequencing procedure is included with each and there are plenty of options for adjusting binning, gain, temperature and offset.



### SKY SAYS...

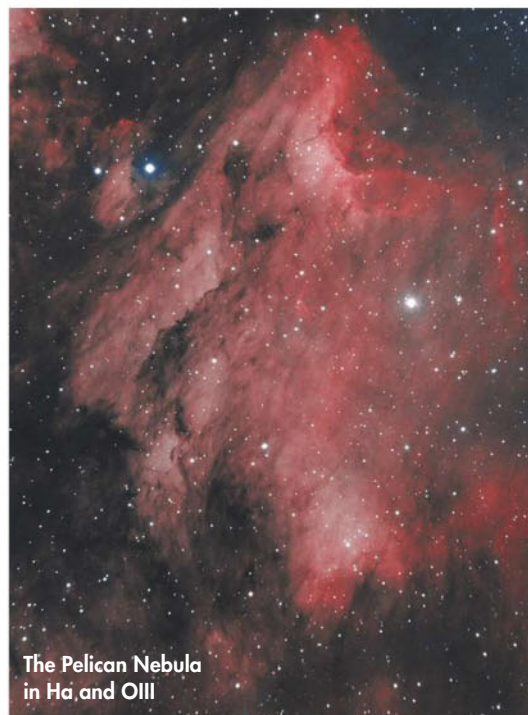
Now add these:

1. Five-slot 36mm colour filter wheel
2. Astronomik LRGB filter set (36mm)
3. Power supply unit

► somewhat weaker in Oxygen III (OIII). We used a Baader 7nm Ha filter and an 8.5nm OIII filter to produce a false colour image by mapping Ha to red and OIII to both green and blue to produce our final RGB colour image.

The KAF-8300 sensor responds very well to cooling – we used its set point cooling feature to reach  $-20^{\circ}\text{C}$ . There were no bad columns but typical of this sensor, there were some hot pixels. In post processing, these were simply removed by the dual actions of dithering the exposures and stacking our subframes using a method that removes the more outlier pixels. This resulted in an image with plenty of detail and fairly realistic colours despite the use of narrowband filters. The camera was very sensitive and once we had got used to the rather unusual ‘plopping’ noise from the mechanical sliding shutter, which served to confirm that exposures were in progress, we had an uneventful imaging session with the camera performing perfectly throughout.

There is also an anti-blooming gate, which stops vertical bleeding from fully saturated pixels so we put this to the test by imaging the Moon, which allowed us to capture short exposures yet plenty of photons. The sensor



The Pelican Nebula in Ha and OIII

performed well here too, capturing crisp and clear images with no sign of bleed.

We were very impressed with the performance of the camera despite its rather ordinary appearance and would recommend to both astrophotography beginners and those upgrading from a DSLR camera to their first CCD camera. **S**

## VERDICT

BUILD & DESIGN	★★★★★
CONNECTIVITY	★★★★★
EASE OF USE	★★★★★
FEATURES	★★★★★
IMAGING QUALITY	★★★★★
OVERALL	★★★★★

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# Books

New astronomy and space titles reviewed

## RATINGS

- ★★★★★ Outstanding  
 ★★★★★ Good  
 ★★★☆☆ Average  
 ★★☆☆☆ Poor  
 ★☆☆☆☆ Avoid

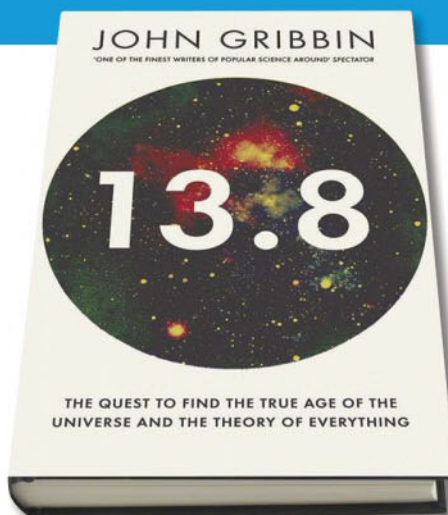
### 13.8

John Gribbin  
 Icon Books  
 £16.99 • HB

Just a century ago, humankind was completely clueless as to the origin of the Universe. But now, not only do we have a pretty good idea how the Universe started, we also know precisely when it started. This book, entitled simply *13.8*, shows how we have arrived at the fascinating conclusion that the Universe is precisely 13.8 billion years old.

Author John Gribbin begins by discussing one of the most interesting and compelling results of modern science: that the calculation of the ages of the oldest stars using the precepts of quantum mechanics agrees very well with calculations of the age of the Universe using general relativity. The fact that these two theories, which currently defy elegant unification, are in complete agreement is indeed a major success for science. Perhaps disappointingly though, Gribbin doesn't return to this point in the concluding sections of his book.

Instead, in his inimitable style, he leads us on the journey promised in his introduction. There is a goal to reach in this book. But to get there we need to explore almost all of modern astronomical knowledge and understand its historical development. So we journey through the development of spectroscopy, atomic theory, quantum theory and stellar nucleosynthesis, learning how basic measurements can be used to determine the ages of stars and globular clusters.



Next we tackle the subjects of distance determination, galactic and extragalactic dynamics, and the development of general relativity and cosmological models. We cover everything we need to see how that one

number has come to be defined. At each juncture, we are lucidly told how new knowledge has added to our wealth of evidence concerning the age of the cosmos.

Like a good crime novel, *13.8* reveals the truth of the matter on the last three pages. Unfortunately, the final chapter seems rushed and not quite as revealing as it should. The history is

important, but there is much missing in the final revelation of more recent cosmology. Nevertheless, interested amateurs will get great enjoyment from following this story and will undoubtedly be inspired to delve deeper into this fascinating area of science.

★★★★★

DR ALASTAIR GUNN is a radio astronomer at the Jodrell Bank Centre for Astrophysics



### TWO MINUTES WITH JOHN GRIBBIN

What inspired you to write the book?

In the spring of 2013, data from the Planck satellite made headlines. The story run by the media was that 'the Universe is older than we thought'. This caused wry amusement amongst cosmologists. What the data actually told us is that the estimated age had increased from 13.77 billion years to 13.82 billion years, an increase of less than half of one per cent. A generation ago we could only say the Universe was between 10 and 20 billion years old. The precision of the new measurement is half of the most important fact, both in physics, which is the focus of this book, as well as in the wider world of thought.

### Why did you choose to tell the story in numbers?

Well, the story is actually told in words, with key numbers picked out as chapter titles. But I did this because numbers are important and I wanted to do something different from the usual approach in books of this kind.

### How far are we from a theory of everything?

Who can say?! I suspect quite a long way from the famous 'equation you can write on a t-shirt', but as long as quantum physics and relativity theory work in their own areas and do not conflict with one another, I am happy. As an aside, though, I suspect that the 'answer' will be discovered when we have proper quantum computers to do the work; in which case, by 2030.

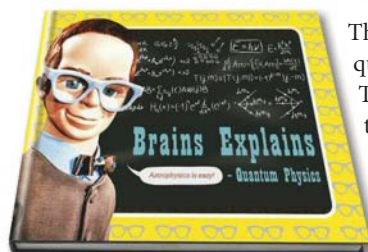
JOHN GRIBBIN is a visiting fellow in astronomy at the University of Sussex and author of many popular science books



**13.8 explores almost all of modern astronomical knowledge**

# Brains Explains Quantum Physics

Ben Still  
Octopus  
£10 • HB



This is a quirky Thunderbirds-themed exploration of quantum physics that keeps the

subject as simple as possible. It tackles everything from the 'lumpiness' of light and stellar radiation to baffling concepts like quantum entanglement and teleportation. Many topics are relevant to astronomy, such as quantum degeneracy pressure, which stops some superdense stars collapsing under their own crushing gravitational pull.

The book ends with a nice discussion of the 'known unknowns' that frustrate scientists to this day – what is the nature of the dark energy that drives the expansion

of the Universe ever faster? What lies at the heart of black holes, and what makes the quantum world so strange and unpredictable to start with? The answers to these questions are stubbornly elusive.

*Brains Explains Quantum Physics* is a reassuringly gentle introduction to a very counterintuitive subject and it's as well explained as it can be. Even the experts often say that if you think you understand quantum mechanics, you really don't. But author Ben Still has made sure Brains flags up the especially bewildering concepts so you don't feel you've simply missed the point.

The book is full of interesting facts and numbers, although a diagram of fundamental particles fluffs the neutrino names. But overall Brains has done a great job, and the book's design and illustrations are great fun. Gordon Tracy may not agree, though – in one graphic, the villainous Hood traps him inside Thunderbird 4 and threatens him with uncertain death in an evil remake of Schrödinger's cat experiment.

★★★★★

HAZEL MUIR is a freelance science writer

# Meteorite: Nature and Culture

Maria Golia  
Reaktion Books  
£14.95 • PB

BOOK  
OF THE  
MONTH



In *Meteorite: Nature and Culture* we are introduced to the science and folklore surrounding the rocks from space that we know as meteorites, but

which were once looked upon as being messengers from the gods. In this well-researched and copiously illustrated book the author looks back in time to discover how the arrival of these celestial visitors, with their 'blazing light and Earth-shaking sounds' induced a sense of awe and wonder in our ancestors.

The book tells the story of meteorites from the time they were worshipped and revered by ancient civilizations through to the eventual acceptance of their true origins by scientists and on to the modern era, where they are now seen as inspiration to writers, artists, filmmakers and more. The rarity of meteorites has encouraged interest and passion, not only in the scientists who examine them for clues as to the origins of the Solar System and how they have helped to shape our planet, but with collectors and artists who have seemingly developed an addiction for these scarce and highly desirable objects.

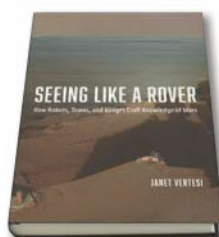
Author Maria Golia introduces us to a large number of meteorite aficionados and scholars, hunters and collectors, including the meteorite enthusiast and former punk rock musician Geoffrey Notkin who, we are informed, once said that "like the sound of the ocean in a seashell, meteorites carry within them a faint murmur of infinity". Notkin's words sum up the fascination we have with meteorites; a fascination that this book puts across very well.

★★★★★

BRIAN JONES is the author of 15 books on astronomy and space

# Seeing Like a Rover

Janet Vertesi  
University of Chicago Press  
£24.50 • HB



This is a detailed, academic account of image processing and analysis from Mars rover cameras. Author and sociology professor Janet

Vertesi had almost unrestricted long-term access to the mission control rooms and image processing centres for NASA's Spirit and Opportunity Mars rovers. Her brief was to describe how the camera data is interpreted and how the systems were designed to bridge the gap between machine vision and human senses. There is plenty of decent detail here for those with a technical bent.

Unfortunately, Vertesi's text sometimes fences itself off from the average reader with a prickly shield of sociologist's babble. She describes the rover operators'

experience of their mission as "mediated through earthbound visual transformations". We learn that the "bodily practices of visual sense-making and other associated interactions play a central role in reproducing the team's collective orientation". Even one of the reviews on the back of the book highlights "the conjoining of humans and non-humans in relations of mutual transformation".

Academic phrasing of this kind is a poor substitute for elegant English. Worse still, Vertesi's account of semi-intelligent robots traversing Mars and transmitting to us a virtual experience of an alien world lacks that key ingredient for a good story: dramatic tension.

Another worrying flaw in such an expensive book about 'seeing' is the scarcity of images. A handful of illustrations pepper this densely written work. There's no doubt that sociologists with an interest in space mission planning will be riveted, but for general readers it's a bumpy ride.

★★★★★

PIERS BIZONY is the author of *The Space Shuttle and other books on spaceflight*

# Gear

Elizabeth Pearson rounds up the latest astronomical accessories



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## 3 Timeline: Science and Discoveries

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# WHAT I REALLY WANT TO KNOW IS...

## Where did comets get their dust?



**Ryan Ogliore** is studying tiny grains sent home by a space probe to learn about the origins of these cosmic nomads

INTERVIEWED BY PAUL SUTHERLAND

**E**SA's Rosetta spacecraft and its study of comet 67P/Churyumov-Gerasimenko has been dominating headlines in the world of space science in recent months, but there is another comet I am hoping will also spill its secrets: Wild-2, which was visited by NASA's Stardust mission in January 2004.

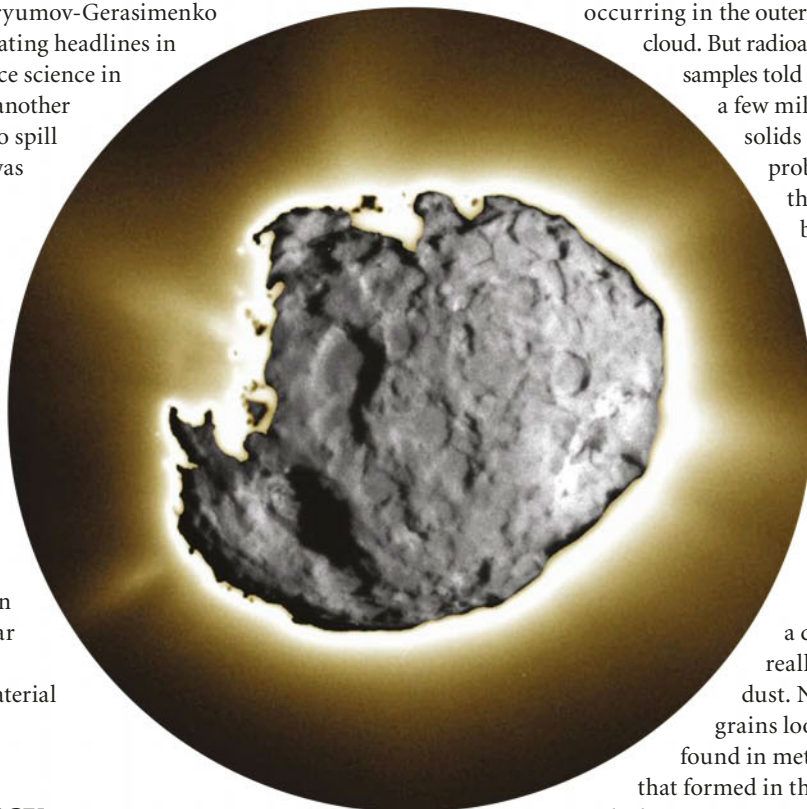
My colleagues and I have been examining microscopic fragments of this icy visitor brought back to Earth by Stardust.

The grains of dust collected by Stardust have presented us with a mystery. That's because Wild-2 is known to have spent most of its existence in the depths of the outer Solar System, beyond Neptune, yet it appears to contain material that is commonly found in the inner Solar System.

### Dusty discrepancy

Stardust came within 240km of Wild-2's nucleus, collecting dust with a gel-covered device resembling a fly swatter. We imagined that this dust would either be primitive material from the origin of the Solar System or grains from interstellar space that formed around other stars. However, we found that while the larger dust resembled the material found in ancient meteorites called chondrites, the smaller grains were more mysterious. They were potentially a diverse sampling of inner Solar System rocks, or possibly the primitive building blocks of our Solar System.

Our Solar System formed from a spinning molecular cloud. After it collapsed, the young Sun was left surrounded by a rotating disc of dust and gas, which it began to suck in. The material falling onto the Sun was rotating, so must have had angular momentum. That would have sent some of the gas moving outwards, towards the outer Solar System, and some of the dust must have come along for the ride. This is probably how the igneous rocks that we see in fragments collected by the Stardust mission ended up in comet Wild-2.



**Wild-2 only began travelling through the Solar System in 1974, after a near miss with Jupiter altered its orbit**

### ABOUT RYAN OGLIORE

Having worked as a researcher at the Hawaii Institute of Geophysics and Planetology, Ryan Ogliore is now an assistant professor at Washington University in St Louis, where he continues his quest to learn more about the origin of the Solar System.

It is difficult to think of these igneous processes occurring in the outer regions of the original gas cloud. But radioactive decay in one of these samples told us that it formed at least a few million years after the first solids in the Solar System. The problem with this is that most theories have Jupiter forming by this point, and because Jupiter is so big, it essentially cuts off that outward migration of gas and dust. So either Jupiter had to form later, the dust and gas had to be launched above or below Jupiter's orbit, or the grains had to have formed in the outer Solar System. Our research suggests a difference between the really fine dust and the larger dust. Nearly all of the larger grains look like igneous rocks found in meteorites from asteroids that formed in the inner Solar System, and when we measure the oxygen isotopic composition of these grains, they match the compositions of igneous rocks in meteorites.

The fine-grained dust looks totally different, spanning the range of everything we've ever seen in the Solar System, from the composition of the Sun to mysterious things found in one meteorite that probably came into contact with water in the outer Solar System. And all these compositions were present in tiny dust grains just fractions of a millimetre from each other! To find these compositional signatures in known inner Solar System material, we have to take some oxygen from the Sun, some oxygen from igneous rocks found in primitive meteorites and some oxygen from an exotic phase identified in a meteorite that was found in the Algerian desert in 1990.

It could be that the cometary finds are a mixture of all this stuff from the inner Solar System that was transported to the outer Solar System or it may tell us something new about the primitive building blocks of the Solar System. My team is busy trying to find out the answer. **S**



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All prices correct at time of press. Subject to change. Errors and omissions excepted.

# The Southern Hemisphere in October



With Glenn Dawes

## WHEN TO USE THIS CHART

1 SEP AT 00:00 UT  
15 SEP AT 23:00 UT  
30 SEP AT 22:00 UT

The chart accurately matches the sky on the dates and times shown. The sky is different at other times as stars crossing it set four minutes earlier each night. We've drawn the chart for latitude  $-35^\circ$  south.

## OCTOBER HIGHLIGHTS

From eastern Australia on the morning of the 9th, Venus is briefly occulted by the Moon. The disappearance occurs behind the bright limb of the thin lunar crescent in the dawn sky. Eastern cities see this naked-eye event around 04:30 EST (05:30 daylight saving). It reappears from the dark lunar limb after sunrise around 80 minutes later. To see Venus's return only requires binoculars, however for comfort and safety it is recommended to hide the Sun behind a building or tree.

## THE PLANETS

The only bright planet visible in the evening is Saturn, low in the early western sky and dropping quickly. By month end this ringed wonder will be a twilight object only. Things go quiet until a burst of activity in the pre-dawn. Venus

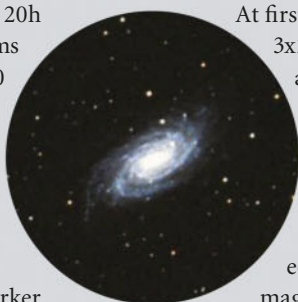
## STARS AND CONSTELLATIONS

In his 1603 star atlas *Uranometria*, Johann Bayer popularised 12 constellations in the far south, all visible in October evenings. Five are birds: Apus, Grus, Pavo, Phoenix and Tucana; two reptiles: Hydrus and Chamaeleon; and two fish: Dorado and Volans. The three left are Indus the Indian, Musca the Fly and Triangulum Australe the Southern Triangle. Seeing all 12 is only possible since Volans, Chamaeleon, Musca and Triangulum Australe are circumpolar from mid-latitude Australia.

rises around 03:30 EST and is soon followed by Jupiter and Mars, rising out of the dawn glow. The three planets fit within a  $5^\circ$  circle from the 22nd to the end of the month. The spectacular highlight is on 26th, when Venus and Jupiter are only  $1^\circ$  apart.

## DEEP-SKY OBJECTS

Start at mag. +3.4 Beta ( $\beta$ ) Pavonis and look  $2.6^\circ$  south to find mag. +5.4 Sigma ( $\sigma$ ) Pavonis (RA 20h 49.3m, dec.  $-68^\circ 47'$ ). It forms a wide double with mag. +7.0 HR 197569 two arcminutes southwest, its orange hue contrasting well with the yellowish-white colour of the dimmer star.



Only  $0.4^\circ$  west of the star is NGC 6943 (RA 20h 44.5m, dec.  $-68^\circ 45'$ ; pictured).

At first glance this mag. +11.4,  $3 \times 2$ -arcminute oval appears as a homogeneous glow, but 150x magnification will show a brightening towards a hazy nucleus. Hop  $0.5^\circ$  southeast of Sigma Pavonis to find edge-on spiral IC 5052, a mag. +11.2 ghostly white streak measuring  $5 \times 0.5$  arcminutes.

Sigma Pavonis is a marker for two interesting galaxies.

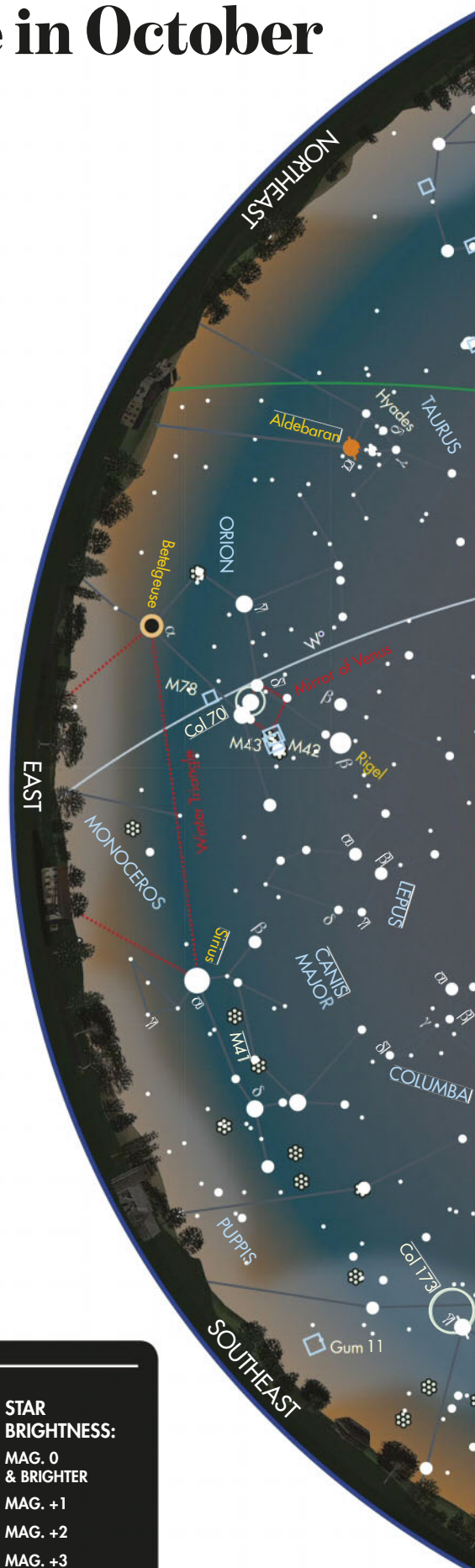
## CHART KEY

GALAXY  
 OPEN CLUSTER  
 GLOBULAR CLUSTER  
 PLANETARY NEBULA

DIFFUSE NEBULOSITY  
 DOUBLE STAR  
 VARIABLE STAR  
 COMET TRACK

ASTEROID TRACK  
 METEOR RADIANT  
 QUASAR  
 PLANET

STAR BRIGHTNESS:  
 MAG. 0 & BRIGHTER  
 MAG. +1  
 MAG. +2  
 MAG. +3  
 MAG. +4 & FAINTER





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## This booklet has two aims:

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- to guide you in the decisions you will make about your care with your doctor.

**It cannot replace talking to your GP or hospital doctor.**

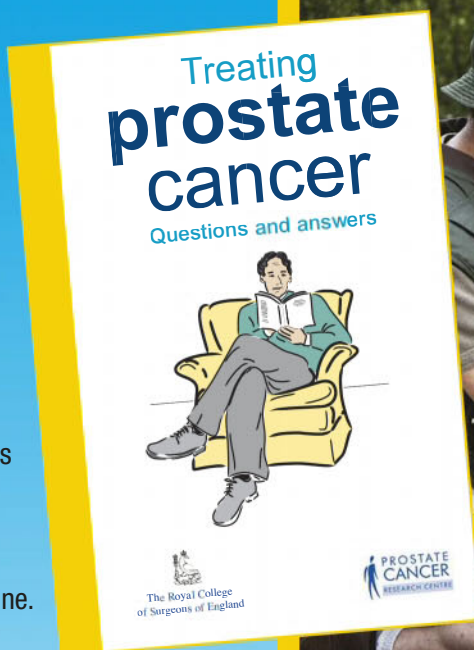
## Symptoms of prostate problems

Listed below are some of the symptoms which are usually caused by benign disease, not prostate cancer. So do not worry if you have any of these symptoms but go to your doctor to have them checked.

- Difficulty or pain in passing urine.
- Having to rush to the toilet to pass urine.
- Frequent visits to the toilet, especially at night.
- Starting and stopping while urinating.
- Dribbling urine.
- A feeling of not having emptied the bladder fully.
- Blood in your urine.

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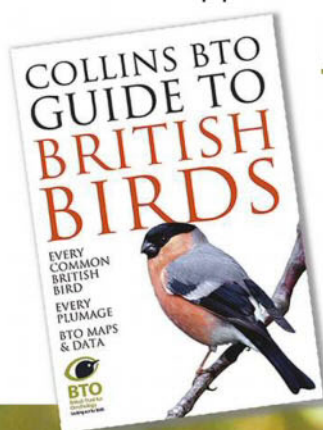
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